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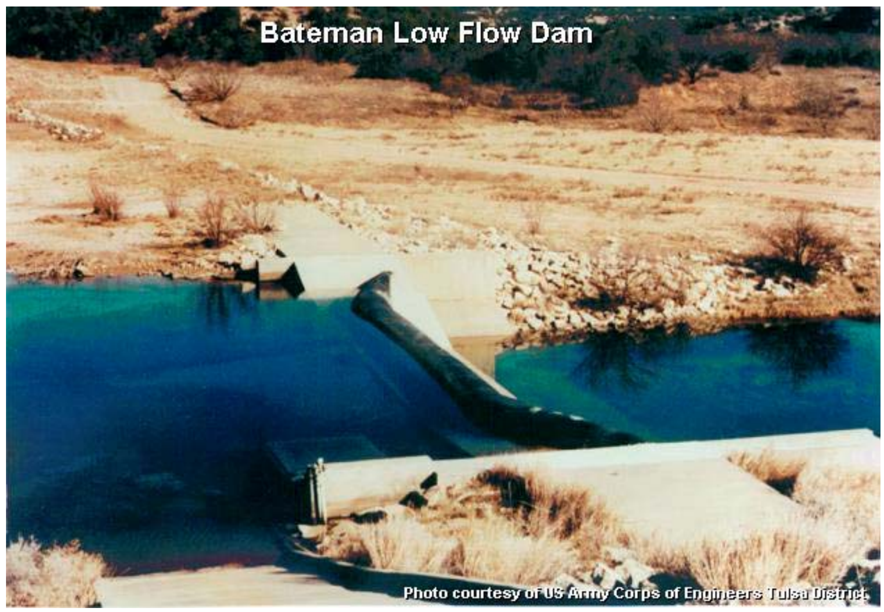
SUPPLEMENT TO FINAL ENVIRONMENTAL STATEMENT FOR THE AUTHORIZED RED RIVER CHLORIDE CONTROL PROJECT WICHITA RIVER ONLY PORTION

VOLUME I



US Army Corps of Engineers ®
Tulsa District

June 2002

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SUPPLEMENT TO THE FINAL ENVIRONMENTAL STATEMENT FOR THE AUTHORIZED RED RIVER CHLORIDE CONTROL PROJECT WICHITA RIVER ONLY PORTION

The responsible lead agency is the U.S. Army Corps of Engineers, Tulsa District.

<u>ABSTRACT</u>

The U.S. Public Health Service initiated a study in 1957 to locate the natural chloride sources and determine the contribution of chlorides from individual areas to the Wichita River. The U.S. Army Corps of Engineers (USACE), entered the study in 1959 and recommended measures to control the natural chloride sources. Plans for chloride control on the Wichita River were known as Part I and were authorized by Congress in 1966. Eight years later, in 1974, funds were allotted by the Water Resources Development Act (Public Law 93-251) to construct portions of Part I. Construction began in 1977 and Area VIII brine collection facility and its associated disposal site, Truscott Brine Disposal Reservoir, became operational in 1987.

A Final Environmental Statement (FES) for the Red River Chloride Control Project (RRCCP), dated July 1976 and of which the Wichita River was a portion, was filed with the Environmental Protection Agency on May 18, 1977, and published in the Federal Register on May 27, 1977. Economic reevaluations have been completed several times since 1976 and have confirmed the proposed project's effectiveness. An environmental reevaluation was approved in 1997 and in 1998, the National Environmental Policy Act (NEPA) scoping process was initiated.

Facilities already constructed include a ring dike at Estelline Springs (Area V); the low-flow collection dam on the South Fork of the Wichita River (Area VIII); and Truscott Brine Disposal Reservoir on Bluff Creek, a tributary of the North Fork of the Wichita River near Truscott, Texas. The Area X (Lowrance) low-flow collection dam and pump station, which would use Truscott Brine Disposal Reservoir as a disposal site for the brines, has been completed. However, this facility is not operational as construction of the necessary pipeline, pumps, and controls has not been started. Funds have been appropriated to complete design and begin construction of the remaining authorized facilities at Areas VII, X, and the Truscott Brine Disposal Reservoir in Texas.

The authority to construct the proposed project is contained in the following:

- Section 203, Flood Control Act of 1966, Public Law 89-789, November 7, 1966, Arkansas-Red River Basins, Texas, Oklahoma and Kansas, Part 1.
- Section 201, Flood Control Act of 1970, Public Law 91-611, November 31, 1970, Arkansas-Red River Basins Water Quality Control Study, Texas, Oklahoma and Kansas, Part II.
- Section 74, Water Resources Development Act of 1974, Public Law 93-251, March 7, 1974.
- Section 153, Water Resources Development Act of 1976, Public Law 94-587, October 22 1976.
- Section 1107, Water Resources Development Act of 1986, Public Law 99-662, November 17, 1986, General Design Phase I Plan Formulation, Volumes I and II (DM 25, November 1980).

This supplement was prepared to address significant environmental issues and project design changes, including:

- deletion of brine collection at Areas VI, IX, XIII, and XIV,
- changes in brine disposal locations for Area VII,
- changes in the pool size at Truscott Brine Disposal Reservoir,
- changes in proposed land use at Crowell Mitigation Area, and
- changes in methods of collection and disposal at Areas VII and X.

This supplement addresses potential environmental impacts of implementation and operation of chloride control measures on the hydrological, biological, and water quality components of the North, Middle and South Forks of the Wichita River; the lower Wichita River; the upper Red River downstream of its confluence with the Wichita River to Lake Texoma and Lakes Kemp, Diversion, and Texoma. This supplement also addresses the potential environmental impacts associated with increased selenium concentrations at Truscott Brine Disposal Reservoir, impacts on Federally-listed threatened and/or endangered species, fish and wildlife mitigation, and unquantifiable/undefined impacts.

A number of related documents along with background information on this supplement is available at:

http://www.swt.uasce.army.mil/LIBRARY/Library.CFM.

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SUMMARY

GENERAL

In 1957, The U.S. Public Health Service initiated a study to locate natural chloride seeps and springs and to determine the contribution of these chloride sources to the Red River, to which the Wichita River is a tributary. In 1959, the USACE recommended measures to control identified natural chloride sources. Plans for chloride control were authorized by Congress in 1966. This project was known as the Red River Chloride Control Project (RRCCP). A FES for the RRCCP, dated July 1976 and of which the Wichita River was a portion, was filed with the Environmental Protection Agency on May 18, 1977, and published in the Federal Register on May 27, 1977. Since the 1976 FES, proposed project outputs have changed. Target chloride concentrations of 250 mg/l or less 94% of the time at Lake Texoma and 98% of the time at Lake Kemp were originally established for the proposed project. However, project modifications described in this supplement would affect design effectiveness of the plan evaluated in the 1976 FES. As such, an environmental reevaluation was approved in 1997 and the NEPA scoping process was initiated in 1998. The proposed plan is expected to meet the Texas Natural Resources Conservation Commission (TNRCC) secondary drinking water standard of 300 mg/l chloride 40% of the time at Lake Kemp.

Effectiveness of constructed portions of the project were evaluated by a Congressionally authorized panel, in accordance with Public Law 99-662, to assess the improvement in water quality assumed in the economic reanalysis of the proposed project. The panel submitted a favorable report to the Federal Public Works Committees of the House and Senate in August 1988 indicating that Area VIII was performing as designed. As noted above, design changes have been developed for the proposed project that would lessen impacts on stream flow, water quality, and chloride removal compared to the proposed project evaluated in the 1976 FES. In addition, potential direct and indirect impacts have been identified that were not addressed in the FES.

During the NEPA process for the Supplement to the Final Environmental Statement (SFES), several issues were identified as concerns by the public and commenting natural resource agencies. Major issues addressed in this document include:

1) Hydrological, biological, and water quality issues concerning fish, aquatic invertebrates, aquatic macrophytes, and the wetland/riparian ecosystem of the Wichita River, Lake Kemp, and Red River above Lake Texoma to the confluence of the Wichita River;
2) Lakes Kemp, Diversion, and Texoma components, including chloride/turbidity relationships, chloride/fish reproduction issues, chloride/plankton community issues, chloride/nutrient dynamics issues, and impacts on recreational values;
3) Water quality and quantity impacts on Dundee Fish Hatchery below Lake Diversion;
4) Selenium (Se) concentrations and impacts on biota;
5) Man-made brines and associated reduction;
6) Section 401 water quality issues;
7) Mitigation as it relates to habitat losses from construction of proposed project components;
8) Federally-listed threatened and endangered species; and
9) Unquantifiable/undefined impacts.

Changes in the project base condition have also occurred since the 1976 FES. Due to growing concern in the Wichita River Basin about the availability of water and its effect on economic growth and development, the Red River Authority of Texas (RRA) in cooperation with the Texas State Soil and

Water Conservation Board (TSSWCB) initiated a study to determine the feasibility of implementing a brush control and management program to increase water yield. The goal is to restore large areas of brush to native grasses, but leave brush buffers and habitat corridors composed of mesquite and juniper. The results of the study revealed that implementation of the proposed brush control program may provide a net increase in watershed yield at Lake Kemp ranging from 27.6% to 38.9%. However, brush control would not improve water quality in the Wichita River Basin.

The brush control program has currently been included in Texas Senate Bill 1 and the Region B Water Plan. Implementation is expected to occur regardless of implementation of chloride control measures. This supplement has assumed a brush management factor of 50% implementation as its future condition – with or without chloride control.

FINDINGS

The USACE completed a formal Section 7 consultation with the U.S. Fish and Wildlife Service (USFWS) to address Federally-listed threatened and/or endangered species that occur in the project area. By letter dated March 5, 1999, the USFWS identified the Federally listed species likely to be affected by the proposed project. A Biological Assessment (BA) was prepared by the USACE and submitted to the USFWS in July 2001. The USFWS subsequently issued their Biological Opinion (BO) later the same month. At that time, the USFWS stated that the proposed project should have no effect on threatened and endangered species. In addition, the USFWS has completed a Final Coordination Act Report dated May 8, 2002.

Federal species identified include the whooping crane (*Grus americana*), the bald eagle (*Haliaeetus leucocephalus*), and the interior least tern (*Sterna antillarum*). The whooping crane is a migrant through central Oklahoma and Texas during the fall and spring. Recorded sightings confirm this species' presence during migration in the general area. Additional bird surveys conducted during the fall and/or spring of 1997-1999 at Truscott Brine Disposal Reservoir and the Area VIII collection facility resulted in no sightings of whooping cranes. The interior least tern occurs along major rivers in Oklahoma and Texas as a summer, breeding resident (S2B: 6 to 20 occurrences within the State, very vulnerable to extinction throughout its range) and migrant. Several least terns were sighted at Truscott Brine Disposal Reservoir, though most of these areas appeared to be void of habitat typically suited for this species. The bald eagle is a winter migrant throughout the State of Oklahoma and a winter resident along major rivers and impoundments. No bald eagles were sighted during the intensive bird count surveys completed from 1997-1999 at Truscott Brine Disposal Reservoir and the Area VIII collection facilities.

Flow in a portion of two upper Wichita River basin tributaries would be reduced as a result of diversion of brines at two proposed brine collection facilities. Evaluation of the hydrology with brush management indicates that the proposed project would increase the number of zero flow days in the main stem of the Wichita River by less than 0.05%. Upstream, the project would increase the number of zero flow days 2.3% in the North and Middle Forks of the Wichita River and would increase the number of zero flow days in the South Fork 0.2%. Overall, when the combined effects of the brush management program and the chloride control measures are considered, it would be expected that there would be little effect (adverse or beneficial) on fish communities in the main stem or South Fork of the Wichita River. Within the North and Middle Forks, reduced flows expected as a result of the project should not affect medium and high stream flow, thus the greatest potential for adverse impacts of flow reduction on fish species in the river would be during extreme low flow or zero flow periods.

Salinity reductions in the upper Wichita River may affect salt tolerant fish communities. However, changes in species composition would most likely occur in short-term pulses rather than long-term shifts.

Increases in less salt tolerant species in these areas would most likely be limited to short term pulses resulting from above average rainfall events and associated flow increases. As flows returned to base flow rates of discharge, salinity concentrations would become less favorable for the less salt tolerant species. Evidence of a similar pulse of less salt tolerant fishes into Oscar Creek (Jefferson County, Oklahoma) has been observed (Pezold and Clyde, unpublished data). The fish community in Oscar Creek is very similar to the salt tolerant communities of the Wichita River Basin and is primarily comprised of Red River pupfish, plains killifish, and mosquitofish. Field observations and collections made in May 1994 indicate that fish species more commonly found in less salt tolerant communities can and do move into Oscar Creek for brief periods, as a function of temporal conductivity variations. Subsequent field collections in May 1996 and May 1997 indicate that these movements of less salt tolerant fish species into Oscar Creek occur infrequently, and impacts to the salt tolerant community appear to be minimal. Similar patterns would be expected in the upper Wichita River Basin.

Studies indicate that changes in turbidity, primary productivity, and recreation associated with the chloride control measures in Lake Kemp should be minor. Results of studies aimed at estimating interactions of these impacts do not suggest that major adverse effects would occur. Similar concerns have been raised for Lake Texoma. However, total dissolved solids (TDS) reduction at Lake Texoma would be minor (7% under current concentrations) and impacts to turbidity, productivity, fish communities, and recreation would be expected to be unnoticeable.

Concerns have also been voiced by the Texas Parks and Wildlife Department (TPWD) regarding impacts of chloride reduction on toxic algal blooms. The TPWD Dundee Fish Hatchery gets its water supply from Lake Kemp through Lake Diversion. In recent years, it has been significantly impacted by blooms of a toxic alga which has entered the hatchery system. The golden alga, *Prymnesium parvum,* is a flagellated yellow-green alga and is one of the toxic algae. *P. parvum* blooms, however, have had no documented effect on aquatic insects, animals drinking affected waters, or humans. Chloride changes would probably not have a direct effect on blooms of *P. parvum* (as shown by Larson and Bryant, 1998). However, chloride decreases may favor native non-toxic algal species.

Additional concerns at the Dundee Fish Hatchery are related to potential water supply impacts. Under the Lake Kemp Drought Contingency Plan, the TPWD Dundee Fish Hatchery below Lake Diversion would not receive water from Lake Diversion when Lake Kemp is below elevation 1123 feet National Geodetic Vertical Datum (NGVD). Under with-project conditions, the probability of increased contractual water supply loss increases from 0% to between 11.7 and 14.8%. Supply limitations for hatchery water supply did not exist until development of Senate Bill 1 in 1999 and is not based upon actual water availability. This is a contractual issue established with the Wichita County Water Improvement District No. 2, the City of Wichita Falls, and the TPWD and is documented in legislation. During drought contingency conditions, water continues to be available from Lake Diversion for municipal and industrial use for a fee. Contracts for fee payment or waiver could be developed to allow the Dundee Fish Hatchery to utilize water from Lake Diversion under drought contingency conditions.

The potential for Se accumulation and impacts to biota associated with project areas has also been identified. Selenium occurs naturally in soils and waters of Wichita River Basin and is an extremely complex element in terms of cycling in aquatic systems and impacts on aquatic organisms. Studies conducted by the USACE indicate that there would be at least the potential for Se-related impacts to sensitive or moderately sensitive semi-aquatic bird species breeding at Truscott Brine Disposal Reservoir though risks are not believed to be excessive. Evaluations do not indicate anticipated adverse Se-related impacts on young or adult birds temporarily residing at Truscott Brine Disposal Reservoir. Predicted total Se concentrations over the anticipated 100-year project life are below estimated thresholds for impacts on young or adult birds in the absence of reproductive concerns. Due to the documented ability of birds to rapidly lose Se upon leaving contaminated areas, embryotoxicity for birds overwintering at the reservoir but breeding elsewhere is not anticipated. Modeled Se concentrations for the proposed plan are below estimated threshold values for non-reproductive impacts.

CONCLUSION

Owing to design changes in the original RRCCP, changes in existing project conditions for the study area, amendments to the Endangered Species Act, and the presence of additional species since filing of the FES, it was determined that a supplement to the FES would be required. This study was again coordinated with the resource agencies in accordance with the Fish and Wildlife Coordination Act, and the USFWS issued a Final Fish and Wildlife CAR for the proposed project dated May 8, 2002.

According to the CAR, the USFWS and the TPWD are unable to support the proposed plan in its present form and recommend that it not go forward as formulated. A summary of concerns from the CAR include:

- Alterations in stream hydrology resulting in changes to vegetative species composition, and vegetative encroachment within the stream channel.
- Changes to water chemistry coupled with increased water withdrawals resulting in reduced aquatic species diversity and abundance.
- Changes to chloride levels resulting in reduced productivity at Lakes Kemp, Diversion and Texoma.
- Decreases in chloride levels resulting in losses to recreational fisheries at Lakes Kemp, Diversion and Texoma.
- Construction of chloride control structures resulting in destruction of mesquite-cedar upland habitat.
- Accumulation of Se in Truscott Brine Disposal Reservoir resulting in detrimental impacts to resident and migratory wildlife populations.
- Alterations in stream flow and chemistry resulting in elevation changes and chloride reductions at Lake Diversion and consequent impacts to the TPWD Dundee Fish Hatchery.

The CAR also recommended that alternatives, in addition to the 12 TPWD/USFWS alternatives already evaluated, be reviewed for the proposed project including:

- Deletion of Areas VII or X;
- Collection and reintroduction of brines below Lake Diversion;
- Closure of the existing chloride control measures; or
- Creation of a "hybrid" proposed project which could include blending waters from freshwater sources, reclaimed wastewater, or water from new reservoirs.

According to the CAR, the mitigation of predicted project impacts may be nearly impossible to accomplish in-kind. These impacts included reduced productivity of streams and reservoirs due to reduced chloride levels and increased turbidity. These impacts are unacceptable to the USFWS even with adequate mitigation. The USFWS, TPWD, and Oklahoma Department of Wildlife Conservation (ODWC) are opposed to any reduction in productivity and fisheries at Lake Texoma. However, analysis shows that such impacts should not occur with the proposed plan. The USFWS would not support any alternative until the USACE has developed mitigation measures for impacts to Lake Texoma that satisfy both the TPWD and ODWC.

Since 1991, the USACE has conducted additional environmental studies to address reasonable foreseeable impacts. Based on this technical information, the USACE disagrees with the USFWS as to the severity of impacts attributable to the chloride control measures. The USACE's position with respect to the proposed project remains unchanged for the following reasons:

(1) Project outputs have changed since the proposed project was originally formulated. The proposed project would be operated for target chloride concentrations of 300 mg/l or less 40% of the time at Lake Kemp with minimal reductions in chlorides (10% overall) at Lake Texoma.

(2) Technical data do not substantiate that the proposed plan would have a significant impact on turbidity and primary productivity in Lake Kemp, Diversion, or Texoma. In fact, turbidity impacts at Lake Texoma approach zero. No impacts to turbidity, primary productivity, fisheries or recreation are predicted to occur at Lake Texoma with only minimal, if any, predicted impacts at Lakes Kemp and Diversion.

(3) Additional environmental studies conducted by the USACE during preparation of this DSES indicate some short-term changes to aquatic communities of the upper Wichita River may likely occur, but not with the severity predicted by the USFWS and other natural resource agencies.

(4) The Environmental Operations Plan (EOP) developed for the proposed project establishes comprehensive and scientifically valid methodologies for establishing existing baseline conditions, establishes environmental thresholds and safeguards for many system components, provides long-term monitoring for impacts attributable to the chloride control measures, and protects against unacceptable changes in the Wichita and Red River ecosystems as well as in Lakes Kemp and Diversion. More importantly, it provides a commitment by the USACE to balance authorized project goals with the need to maintain the biological resources throughout the life of the proposed project. The commitments agreed upon in the EOP are summarized in Section 4 of this document.

(5) The fully developed project, as proposed, provides the operational flexibility to meet target chloride concentrations while minimizing impacts to the ecosystem. As part of the EOP, chloride concentrations would be continuously measured at target locations and numerous gaging stations throughout the proposed project area to monitor performance. Results of chloride measurements from this monitoring network would be used to adjust operations at control sites (including elimination of some control sites, if warranted) to balance authorized project goals with the need to maintain biological resources.

(6) The USACE and project sponsor, the RRA, recognize the potential for change to occur within the proposed project area ecosystem with construction and operation of the chloride control measures. However, the USACE believes that the proposed project could be constructed and operated to meet project goals while assuring the continued function and integrity of the ecosystem and as such, under the intent of NEPA and other appropriate environmental laws and regulations, the USACE would: (a) fund and implement the baseline studies and monitoring activities developed and proposed in the EOP, (b) review and act on the recommendations of a peer review committee, and (c) suspend operation of chloride control measures if unacceptable environmental impacts result from construction and operation of the proposed project.

The USACE believes that by implementing appropriate and reasonable mitigation measures as presented in this document and by developing and implementing the EOP, the proposed project should not be discontinued or reformulated.

RELATIONSHIP TO ENVIRONMENTAL PROTECTION STATUES

The relationship of the proposed action to environmental protection statutes and other requirements is shown in Table S-1.

TABLE S-1

RELATIONSHIP OF PLANS TO ENVIRONMENTAL PROTECTION STATUTES AND OTHER ENVIRONMENTAL REQUIREMENTS

Policies	Compliance of Alternatives
Federal	
Archeological and Historic Preservation Act, 1974, as amended, 16 U.S.C. 469, et seq	All plans in full compliance/Additional work required
Clean Air Act, as amended, 42 U.S.C. 7609, et seq	All plans in full compliance
Clean Water Act, 1977, as amended (Federal Water Pollution Control Act), 33 U.S.C. 1251, et seq	All plans in full compliance
Endangered Species Act, 1973, as amended, 16 U.S.C. 1531, et seq	All plans in full compliance
Federal Water Project Recreation Act, as amended, 16 U.S.C. 460-1-12, et seq	All plans in full compliance
Fish and Wildlife Coordination Act, as amended, 16 U.S.C. 661, et seq	All plans in full compliance/Additional work required
Land and Water Conservation Fund Act, 1965, as amended, 16 U.S.C. 4601, et seq	All plans in full compliance
National Historic Preservation Act, 1966, as amended, 16 U.S.C. 470a, et seq	All plans in full compliance/Additional work required
National Environmental Policy Act, as amended, 42 U.S.C. 4321, et seq	All plans in full compliance/Additional work required
Native American Graves Protection and Repatriation Act, 1990, 25 U.S.C. 3001-13, et seq	All plans in full compliance
Rivers and Harbors Act, 33 U.S.C. 401, et seq	All plans in full compliance
Watershed Protection and Flood Prevention Act, 16 U.S.C. 1001, et seq	All plans in full compliance
Wild and Scenic Rivers Act, as amended, 16 U.S.C. 1271, et seq	All plans in full compliance
Water Resources Planning Act, 1965	All plans in full compliance
Floodplain Management (E.O. 11988)	All plans in full compliance
Protection of Wetlands (E.O. 11990)	All plans in full compliance
Farmland Protection Policy Act, 7 U.S.C. 4201, et seq	All plans in full compliance
Environmental Justice (E.O. 12898)	All plans in full compliance
Protection of Children From Environmental Health Risks and Safety Risks (E.O. 13045)	All plans in full compliance
State and Local Policies	
Statewide Comprehensive Outdoor Recreation Plan	All plans in full compliance

NOTE: Full Compliance - Having met all requirements of the statutes, Executive Orders, or other environmental requirements for the current stage of planning.

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Appendices

GLOSSARY OF ACRONYMS

Benefit-to-cost ratio (BCR)
Biological Assessment (BA)
Biological Opinion (BO)
Clean Air Act (CAA)
Coordination Act Report (CAR)
cubic feet per second (cfs)
Draft SFES (DSFES)
Environmental Protection Agency (EPA)
Executive Order (E.O.)
Final Environmental Statement (FES)
Kesterson National Wildlife Refuge (KNWR)
Limited Reevaluation Report (LRR)
micrograms per liter (µg/l)
milligrams/liter (mg/l)
National Agricultural Statistics Service (NASS)
National Ambient Air Quality Standards (NAAQS)
National Economic Development (NED)
National Environmental Policy Act (NEPA)
National Geodetic Vertical Datum (NGVD)
National Register of Historic Places (NRHP)
Natural Resources Conservation Service (NRCS)
Nephelometric turbidity units (NTUs)
Oklahoma Resource Management Plan (OK-RMP).
Oklahoma Statewide Comprehensive Outdoor Recreation Plan (SCORP)
Operation and maintenance (O&M)
Parts per billion (ppb)
Programmatic Memorandum of Agreement (PA)
Red River Chloride Control Project (RRCCP)
Regional Economic Development (RED)
Selenium (Se)
Statement of Findings (SOF)
Texas Natural Resources Conservation Commission (TNRCC)
Texas Outdoor Recreation Plan (TORP)
Texas Parks and Wildlife Department (TPWD)
Texas State Soil and Water Conservation Board (TSSWCB)
Texas Water Development Board (TWDB)
Total Dissolved Solids (TDS)
U.S. Army Corps of Engineers, Tulsa District (USACE)
U.S. Geological Survey (USGS)
US Fish and Wildlife Service (USFWS)
W.T. Waggoner Estate (Waggoner Ranch)
West Texas State University (WTSU)

UNITS OF MEASURE

Units of measure used in this document include:

Unit	Acronym	Application
acres	acres	area
acre-feet	acre-feet	volume
cubic feet per second	cfs	flow
feet	ft	length
meters	m	length
micrograms per liter	µg/l	concentration
mile	mile	distance
milligrams/liter	mg/l	concentration
million gallons per day	mgd	flow
nephelometric turbidity units	NTU	turbidity
parts per billion	ppb	concentration
percent	%	portion
Secchi Disk Depth	m or ft	light penetration in water
surface acres	acres	area

1 PURPOSE AND NEED FOR ACTION.

The proposed chloride control project is a Federal endeavor to reduce the natural occurring levels of chlorides in the Wichita River in Texas. Natural mineral concentrations from the upper reaches of the Wichita River Basin render downstream waters unusable for most beneficial purposes. The primary constituents are chlorides and sulfates. The goal of the project is to improve the quality of the water resources to the extent that they would be more readily usable for municipal, industrial, and agricultural purposes.

Surface and groundwater resources to meet current and future economic growth within the Wichita River Basin are reaching their maximum dependable limits (RRA, 2001). Controlling chlorides presents a practical means to achieve an economically feasible source of water for municipal, industrial, and agricultural purposes and support the water needs of the region (Figure 1-1). Chloride control presents a cost effective and technically feasible means of reclaiming an existing water source to supplement present surface and groundwater supplies. One purpose of chloride control is to prepare for and sustain economic growth and to meet the water resource needs of the demand centers as economically as possible.

The City of Wichita Falls is a major water consumer and a major water supplier within the region. Wichita Falls provides water to several surrounding cities, water districts, industry, and agriculture. Some communities have an immediate need for a supplemental source supply to accommodate present water supply shortages. Because of extended drought conditions experienced in the region, water from Lake Kemp is currently intended for supplemental use along with Arrowhead and Kickapoo reservoirs within the next 3 years. Utilization of Lake Kemp, as modeled in this study, could add up to 61,222 acre-feet of water per year to the present municipal, industrial and agriculture water supplies within the region. Recent studies conducted pursuant to updating the Texas Water Plan have indicated a present and future need for the use of Lakes Kemp and Diversion to supplement existing water supply sources.

Other entities not supplied directly from the Wichita Falls system are considering the use of Lake Kemp with advanced treatment techniques to supplement their existing water supplies until such time as the water quality is sufficiently improved through chloride control. These entities include the cities of Seymour, Vernon, Electra, Harrold, Oklaunion, and several water supply districts.

In summary, the Wichita River system is ideally located to provide supplemental water supply to a multi-county region of North Texas that is expected to collectively require an additional source supply by 2015.

a. History and Authorization of the Chloride Control Projects. The U.S. Public Health Service initiated a study in 1957 to locate natural brine source areas and determine the contribution of brine sources to the Wichita River and Red River. The USACE entered the study in 1959 and recommended measures to control the natural chloride sources. A timeline for the project can be constructed as follows:

- 1957: U.S. Public Health Service directed to locate major sources of natural chloride discharges.
- 1959: Congress directs the USACE to determine if the chloride sources could be controlled and, if so, to determine the costs and benefits of alternative control plans.
- 1962: Experimental work at Estelline Springs (Area V in the upper Red River Basin) authorized.
- 1964: An effective control plan at Area V implemented. Area V used as an indicator of the potential for chloride control in remaining portions of the basin.
- 1966: The USACE reported on chloride control plans for chloride sources in the Wichita River (Areas VII, VIII, and X). These plans were known as Part I and were authorized by Congress the same year.
- 1968: Pre-construction planning started for Phase I.

- 1970: Construction at other areas in the Red River Basin (Part II) authorized, though, to date, construction on these areas has not been initiated.
- 1972: Detailed studies for Phase I completed.
- 1974: Funds allotted by the Water Resources Development Act (Public Law 93-251) for construction at Area VIII and Truscott Brine Disposal Reservoir. (Truscott Brine Disposal Reservoir is a storage reservoir for collected brine.)
- 1976: In accordance with NEPA, a FES for the overall RRCCP completed.
- 1977: FES for Phase I filed with the Environmental Protection Agency (EPA) in May 1977. Construction on Area VIII begins.
- 1978: The USACE requested an economic reanalysis of the entire RRCCP.
- 1986: Congress authorized further construction on the Red River.
- 1987: Area VIII became operational. (Area VIII is currently seen as an indicator of the effectiveness that can be realized with inflatable dam retention and pump-out collection techniques.)
- 1991: A second economic reanalysis requested by the Office of the Assistant Secretary of the Army prior to construction of any other areas outside Area X.
- 1993: Economic reevaluation completed in June confirming economic benefits.
- 1997: Delay ordered in construction of chloride control project for economic reevaluation of Wichita River Basin. This informal economic reevaluation was completed in October 1997 and indicated that a thorough reevaluation of the Wichita River Basin features was warranted based upon the project's economic effectiveness.

The USACE was subsequently approved to undertake a proposed reevaluation of the Wichita River Basin features of the WRCCP to be titled "Wichita River Basin Project Reevaluation" (Reevaluation). Due to changes in the proposed project following the FES filing for the RRCCP, a supplement to the FES was required to comply with the intent of the National Environmental Policy Act (NEPA) as defined in paragraph 1502.9, 40 Code of Federal Regulations (CFR). In 1998, the NEPA scoping process began for the Reevaluation.

The authority to construct this project is contained in the following:

- Section 203, Flood Control Act of 1966, Public Law 89-789, Arkansas-Red River Basins, Texas, Oklahoma and Kansas, Part 1, November 7, 1966.
- Section 201, Flood Control Act of 1970, Public Law 91-611, Arkansas-Red River Basins Water Quality Control Study, Texas, Oklahoma and Kansas, Part II, November 31, 1970.
- Section 74, Water Resources Development Act of 1974, Public Law 93-251, March 7, 1974.
- Section 153, Water Resources Development Act of 1976, Public Law 94-587, October 22, 1976.
- Section 1107, Water Resources Development Act of 1986, Public Law 99-662, November 17, 1986, General Design Phase I Plan Formulation, Volumes I and II (DM 25), November 1980.

b. <u>National Environmental Policy Act Documentation</u>. A FES for the project, dated July 1976, was prepared, distributed for agency and public review, and filed with the Environmental Protection Agency (EPA) on May 18, 1977. The environmental impacts of the RRCCP addressed in the FES were based on environmental studies performed by the University of Oklahoma (1975) and West Texas State University (1972, 1973) under contract to the USACE. The proposed project area is shown on Figure 1-1.

In 1994, due to the length of time between filing the 1976 FES for the RRCCP, initiation of construction of the project, and changes in the study area conditions, as well as in the project design; a supplement to the 1976 FES was required to comply with the intent of the NEPA as defined in paragraph 1502.9, 40

CFR. Paragraph 1502.9 of 40 CFR provides the basis for Federal agencies to determine if a particular action will require a supplement to an existing environmental impact statement by stating,

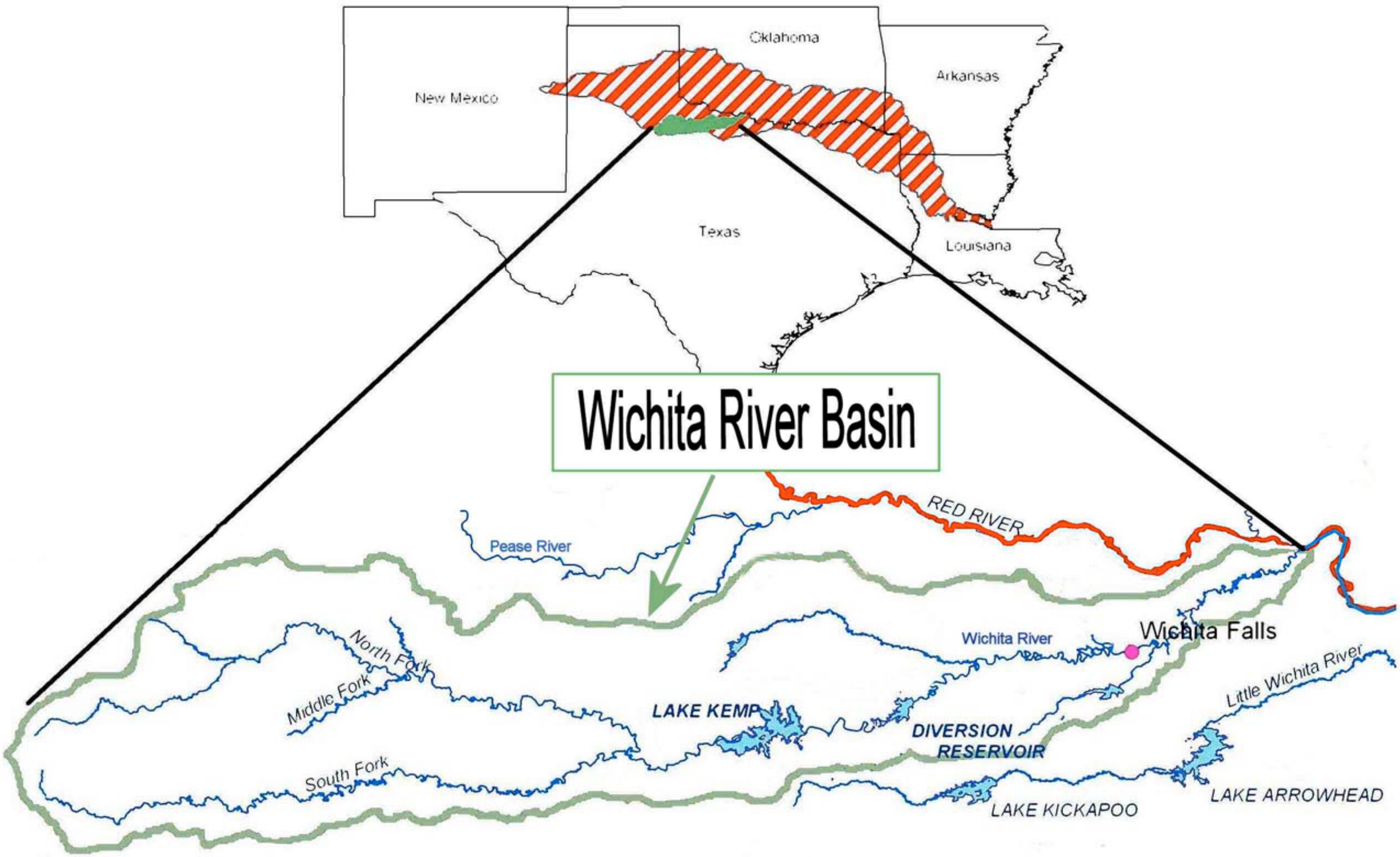
> *"Agencies: (1) Shall prepare supplements to either draft or final environmental impact statements if: (i) The agency makes substantial changes in the proposed action that are relevant to environmental concerns; or (ii) There are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts."*

Subsequently, a Notice of Intent to prepare a supplement to the FES was published in the Federal Register on April 12, 1994. A Draft SFES (DSFES) was prepared and released for public review on April 27, 1995. However, due to geographic shifts in water demand projections, potential impacts upon environmentally sensitive areas along the Red and Pease Rivers, and potential impacts to fish and wildlife species habitat, the final SFES was never coordinated or filed with the EPA. The environmental impacts of the RRCCP addressed in the 1995 DSFES were based on the previous environmental studies as well as those performed by the USACE Environmental Laboratory in Vicksburg, Mississippi (Schroeder and Toro, 1996), the USACE (1993a), and others under contract to the USACE and can be found at http://www.swt.usace.army.mil/LIBRARY/Library.CFM.

In accordance with paragraph 1502.20 of 40 CFR, Ch. V (7-1-91 edition), the District has elected to tie this supplement to the 1976 FES. Subsequently, to avoid repetitive discussions of issues addressed in the 1976 FES and 1995 DSFES, this supplement will only reference issues addressed in the FES, DSFES, and contracted environmental studies and will concentrate primarily on issues specific to subsequent actions. Copies of supporting environmental studies are on file in the Environmental Analysis and Support Branch of the Tulsa District Planning, Environmental, and Regulatory Division. Copies of the 1976 FES and 1995 DSFES are provided at http://www.swt.usace.army.mil/LIBRARY/Library.CFM.

A Notice of Intent to prepare the Wichita River supplement to the FES was published in the Federal Register on July 22, 1998.

FIGURE 1-1.
CHLORIDE CONTROL, WICHITA RIVER BASIN REEVALUATION, TEXAS & OKLAHOMA.



c. Description of Proposed Project. Originally, the authorized RRCCP would have controlled 8 of 10 major natural chloride emission areas to improve water quality for municipal, industrial, and agricultural use. However, the Reevaluation is focused upon the 3 natural chloride emission areas within the Wichita River Basin: Areas VII, VIII, and X (Figure 1-1).

As previously described, Areas VII, VIII and X are on upstream forks of the Wichita River and are the subject of this document. The proposed project facilities consist of 3 low flow dams for collection of brine, 5 spray fields for brine volume reduction, one brine disposal reservoir for holding concentrated brine solutions, and necessary pumps and pipelines to transport brine solutions from the low flow dams to the brine disposal reservoir.

The remaining 5 control areas from the original authorized project, Areas V, VI IX, XIII, and XIV, are either in the floodplain of the Red River or on tributaries of the Red River. Of these, only Area V is addressed in detail in this document because it has already been constructed and remains part of the base condition for the proposed project.

1. Area V. Area V is a large spring in the floodplain of the Prairie Dog Town Fork of the Red River in Hall County, about 0.5 mile east of Estelline, Texas. Chloride control features at this site were implemented in 1964 and are still in operation. Because the facilities have been implemented, are still in operation, and are part of the authorized project, Area V is considered an existing condition and is expected to remain and be functional in the future. Control at this area consists of a ring dike approximately 9 feet high and 340 feet in diameter extending to bedrock around the spring. The dike allows the head to be increased on the spring (approximately 7 feet) so the natural flow is suppressed. Area V produced 300 tons per day of salt. Of these, 240 tons/day are being controlled. A total of 98 acres of land has been acquired for operation of this area.

2. Area VII (Y-Ranch Pump Station). This area would be located at river mile 209.6 on the North Fork of the Wichita River and would have a drainage area of about 492 square miles (Figure 1-1). The brine would be collected through the use of a low flow dam with a 5-foot-high inflatable weir. All low flows would be transported through an intake to a wet well beneath a pump station where they would be pumped through a pipeline to Truscott Brine Disposal Reservoir for evaporation and permanent storage. When stream flows overtop the inflatable dam by 6 inches or more, the weir would automatically deflate and allow the floodwaters to pass downstream. One spray field would be constructed for flow reduction at the pump station intake. The spray field would encompass 24 acres. A second spray field would be constructed at the pipeline outfall. This second spray field would occupy 28 acres. Out of the total of 244 tons/day of salt produced at Area VII, 195 tons/day would be controlled. No facilities at Area VII have been constructed.

3. Area VIII. This site is located on the South Fork of the Wichita River (Figure 1-1). The primary collection area (Bateman Pump Station) is located at river mile 74.9 and has a drainage area of approximately 221 square miles. The brine is collected through the use of a low flow dam with a 5-foot-high inflatable weir which is operated identically to the one described for Area VII. The collected brine is pumped through a pipeline to Truscott Brine Disposal Reservoir for evaporation and permanent storage. A spray field for brine volume reduction currently operates at the pipeline discharge at Truscott Brine Disposal Reservoir. A second spray field would be constructed at the Area VIII pump station intake and would occupy 37 acres. Out of the total of 160 tons/day of salt produced at Area VIII, 160 tons/day are controlled. This portion of the authorized project has been constructed and is currently in operation.

A secondary collection area (Ross Pump Station) at Area VIII has been authorized if needed, and would be located at river mile 61.5, with approximately 396 miles of drainage area. The physical features of the Ross Pump Station would be the same as that described for the Bateman Pump Station, including the brine disposal reservoir (Truscott). However, construction of the secondary collection facility (Ross Pump Station) has been deferred indefinitely.

4. Area X (Lowrance Pump Station). This area is located at river mile 20.5 on the Middle Fork of the Wichita River and includes a drainage area of approximately 60 square miles (Figure 1-1). The brine would be collected through the use of a low flow dam with a 5-foot-high inflatable weir which would also operate identically to the one described for Area VII. The collected brine would be pumped through a pipeline to Truscott Brine Disposal Reservoir for evaporation and permanent storage. A second spray field would be constructed at the pipeline intake and would occupy 32 acres. A spray field at the pipeline outlet would occupy 28 acres of land. Out of the total of 58 tons/day of salt produced at Area X, 49 tons/day would be controlled. The Area X (Lowrance) low-flow collection dam and pump station have been completed, but construction has not begun on the pipeline, pumps, or controls to transfer the brine solutions from Area X to Truscott Brine Disposal Reservoir.

5. Truscott Brine Disposal Reservoir. The reservoir is located at river mile 3.6 on Bluff Creek, a south bank tributary of the North Fork of the Wichita River, and has a drainage area of approximately 26 square miles (Figure 1-1). Truscott Brine Disposal Reservoir was originally designed as a total retention impoundment for the permanent storage of brine from Areas VIII and X. The dam is an earth-filled embankment approximately 15,500 feet long with a maximum height above the streambed of 107 feet. The spillway is of an excavated, uncontrolled, saddle type. It is 1,000 feet long with the crest established at the top of the flood control pool for the 100-year event. Although the reservoir is not designed to release brine, the spillway is included as a safety feature to ensure that the embankment will not fail in the event of an exceptionally large rainfall event. The brine pool could ultimately cover 3,700 acres at elevation 1510.4 feet NGVD. A total of 3,932 acres of land has been acquired for operation of this brine storage reservoir.

d. Description of Design Changes Since Authorization. Funds have been appropriated to complete design and begin construction of the remaining authorized facilities at Areas VII and X. Since filing the FES, several changes have occurred within the project area and in the project design. Detailed descriptions of these changes by area are as follows:

No changes to Area V or Area VIII and its conveyance structures would occur, as these are already in operation. A spray field of 37 acres would be added at Area VIII.

Area VII brine collections would be pumped directly to the Truscott Brine Disposal Reservoir for permanent storage instead of being pumped to Crowell Brine Reservoir. Crowell Brine Reservoir would be eliminated as a storage reservoir, since under the proposed plan none of the other areas previously proposed to discharge to Crowell Brine Reservoir would be constructed. This would result in installing a pipeline in a new location from Area VII to the Truscott Brine Disposal Reservoir, a distance of approximately 15 miles. Twenty acres of land would be required for construction and operation of these facilities at Area VII while 24 acres would be needed for spray field construction at the pipeline intake. An additional 181 acres would be required for pipeline installation and 28 acres for spray field operation at the pipeline discharge. The area formerly identified and purchased for construction of Crowell Brine Reservoir would all be utilized for mitigation of wildlife resources.

Area X brine collections would be pumped **directly** to the Truscott Brine Disposal Reservoir for permanent storage instead of being pumped to Truscott via an intersection with the existing Area VIII pipeline. This would result in the installation of a new 10.4-mile pipeline. Spray fields would be constructed at the pipeline inlet and outlet. A total of 178 acres of land would be required for construction and operation of these facilities for Area X.

A tabular summary of currently proposed project features and design changes related to the proposed project is shown in Table 1-1. The component locations are described in Table 1-2. The authorized project with these design changes is the proposed chloride control project.

e. Economic Basis for Authorized Project. To evaluate the effectiveness of the proposed project in improving the quality of water for beneficial purposes, an economic evaluation was performed in accordance with Section 103 of the Water Resources Planning Act, as amended (42 U.S.C. 1962a-2), "Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies". This evaluation is contained in "Supplemental Data to Arkansas-Red River Basin Chloride Control, Red River Basin, Design Memorandum No. 25, General Design, Phase I - Plan Formulation", Volumes I and II, Department of the Army, Tulsa District, Corps of Engineers, Oklahoma, dated November 1980. The 1980 evaluation was updated and is contained in the Limited Reevaluation Report (LRR) dated June 1993. In 2001 the evaluation was updated again to address only the Wichita River and is included by reference at http://www.swt.usace.army.mil/LIBRARY/Library.CFM.

The Federal objective is to contribute to National Economic Development (NED) while protecting the Nation's environment pursuant to Federal Statutes, executive orders, and planning requirements. The general management standard of the value of goods and services is defined as the willingness of users to pay for each increment of output from a plan. The optimum NED plan identifies beneficial and adverse effects on the economy and reasonably maximizes net NED benefits. This is the proposed plan presented in Section 2.

Regional Economic Development (RED) impacts that register positive and negative changes in distribution of regional economic activity, such as expenditure impacts on regional income and regional employment, are discussed in Section 4.0 of this document. The benefit-to-cost ratio (BCR) is based on NED effects on the national economy. The most recent cost-benefit analysis for the proposed plan shows the project to be economically justified and is included in the Reevaluation Report for the project.

1. Beneficial Effects. The beneficial effects of the NED plan are increases in the economic value of the national output of goods and services from the plan; the value of output resulting from external economies caused by a plan; and the value associated with the use of otherwise unemployed or underemployed labor resources. National economic development benefits for chloride control include water quality improvement for municipal and industrial water supply and agricultural irrigation. Recreation and commercial or sport fisheries may also experience beneficial impacts.

Measurement of NED benefits occurs in those counties that may be economically affected by the proposed project (Figure 1-1). The counties in the study area are either existing or potential users of Wichita/Red River water for one or more of the following reasons:

- The projected demand for water in some counties exceeds the existing source capabilities; therefore, alternatives must be considered;
- Proximity to the Wichita/Red River or a major tributary makes water conveyance costs low such that use of the river is economically feasible compared to alternative sources;
- Current and past activities document that the Wichita/Red River is a viable alternative water source for the Dallas-Fort Worth metropolitan area; and

- There is a lack of readily available viable alternatives to the Wichita/Red River as a water source for some counties.

Municipal and industrial NED benefits are measured as water quality improvement benefits and water supply benefits. Water quality benefits are derived when Wichita/Red River water is used. The benefit is a measure of the quality cost of water (either the cost of treatment to an acceptable standard or the damage cost as a result of no treatment) without the project as compared to cost of water with the project. A water supply benefit results if Wichita/Red River water were to be used only with project implementation. The resulting benefit is equal to the cost of Wichita/Red River water minus the next least costly alternative for water supply with the project.

Agricultural irrigation benefits equal the difference in net crop returns with the proposed project minus the net crop returns without the proposed project. As such, it is necessary to project the type and amount of crops expected to be grown over the project life with and without the proposed project. The basic assumption behind the forecast of cropping patterns for both with and without the proposed project is that they would be based on providing the maximum possible net revenue to the farmer. The combination of crops that would provide the maximum possible net revenue is the optimal crop mix. An optimal crop mix is estimated for each reach, with irrigable land (acreage of each soil type) and irrigation water as resource constraints. Differences in net revenues occur primarily from higher yields resulting from increased irrigation with water of improved quality.

2. Adverse Effects. The adverse effects of the proposed plan with respect to NED are the resources used in implementing the plan, such as implementation outlays, associated costs, and other direct costs. One adverse effect would be land use changes from spray field construction and operation.

3. Speculative Effects. Potential NED economic impacts on public recreation, such as Lake Kemp recreation and on other stream and lake uses as a result of water quality changes depend on documentation of baseline and future conditions as outlined in the EOP. At the present time, many of these changes are speculative or unquantifiable. However, efforts have been made to develop an accurate analysis of the relationship between water quality and recreation economics as detailed in Section 4 of this document.

f. Issues Addressed. Major issues addressed in this document were categorized into the following components and include: (1) hydrological, biological, and water quality issues concerning fish, aquatic invertebrates, aquatic macrophytes, and the wetland/riparian ecosystems of the Wichita River and Red River above Lake Texoma to the confluence of the Wichita River; (2) the Lake Kemp, Lake Diversion, and Lake Texoma components, including chloride/turbidity relationships, chloride/fish reproduction issues, chloride/plankton community issues, chloride/nutrient dynamics issues, and impacts on recreational values; (3) a Se component addressing concentrations and impacts on biota; (4) man-made brines and associated reduction; (5) Section 401 water quality issues; (6) mitigation as it relates indirectly to habitat losses resulting from irrigated cropland and direct impacts resulting from construction of project components; (7) Federally-listed threatened and endangered species; (8) unquantifiable/undefined impacts, and (9) water quality and quantity impacts to Dundee State Fish Hatchery.

TABLE 1-1

SUMMARY OF PROPOSED FEATURES FOR THE WICHITA RIVER ONLY PORTION OF THE AUTHORIZED RRCCP

Area	Authorized Plan	Proposed Plan
AREA V (Estelline Springs)		
Collection	Ring Dike, 9 feet high and 340 feet diameter. Natural flow suppression.	No change
Real Estate	98 acres	No change
AREA VII (Y-Ranch Pump Station)		
Collection	Low-flow collection dam. Deflatable, fabric-type weir.	No change.
Pump Station	Two electric motors with vertical multi-stage turbines and discharge capacities of 9,000 and 3,800 gal/min.	Three vertical turbine pumps providing a maximum flow rate of 9,200 gal/min.
Pipeline	One 33-inch-diameter pipeline, approximately 12 miles long.	One 20- to 24-inch-diameter steel pipeline, approximately 15 miles long.
Disposal	Crowell Brine Reservoir - 100-year storage pool at elevation 1494.0 NGVD (see Area IX)	Truscott Brine Disposal Reservoir 100-year pool at elevation 1505.0 NGVD.
Real Estate	Approximately 230 acres	307 total acres, not including disposal required.
Intake and Discharge Spray Fields	Not Included	Overhead discharge nozzles for 25% volume reduction

TABLE 1-1 (Continued)

Area	Authorized Plan	Proposed Plan
AREA VIII (Bateman Pump Station)		
Collection	Low-flow collection dam. Deflatable, fabric-type weir.	No change (constructed).
Pump Station	Three vertical turbine pumps with discharge capacities of 2,244 gal/min.	No change (constructed).
Pipeline	One 30-inch-diameter pipeline 21.9 miles long.	No change (constructed).
Disposal	Truscott Brine Disposal Reservoir	Truscott Brine Disposal Reservoir as constructed plus 2 spray fields (collection and discharge points).
Real Estate	4,430 total acres required (192 pump station, 306 pipeline, 3,932 disposal)	As constructed plus 74 acres for spray field construction and overspray
Intake Spray Field	Not Included	Overhead discharge nozzles for 25% volume reduction
AREA X (Lowrance Pump Station)		
Collection	Low-flow collection dam. Deflatable, fabric-type weir.	No change (constructed).
Pump Station	Two pumps, with discharge capacities of 4,500 gal/ min. and 1,800 gal/min.	Three vertical turbine pumps from 150 to 200 horsepower providing a total pump station flow of 1,800 to 4,500 gal/min.
Pipeline	One 30-inch-diameter pipeline, approximately 8 miles long.	One 18-inch-diameter steel/PVC pipeline, approx- imately 10.4 miles long.
Disposal	Truscott Brine Disposal Reservoir	No change (constructed).
Real Estate	280 total acres required.	210 total acres required
Intake and Outfall Spray Fields	Not Included	Overhead nozzles for 25% volume reduction

TABLE 1-2

WICHITA RIVER ONLY PORTION OF THE RRCCP COMPONENT LOCATIONS

Description of Collection/Disposal Areas	River Mile	Latitude/ Longitude	Collection Facility Location
AREA V			
Collection Area	1074.5	34° 33’ 50” 100° 25’ 22”	Located 3/4-mile east of Estelline, Texas, and 1 mile south of the Prairie Dog Town Fork of the Red River.
AREA VII (Y-Ranch Pump Station)			
Collection Area	209.6	33° 56’ 21” 100° 03’ 17”	Located on the North Fork of the Wichita River near Crowell, Texas, in Cottle County.
AREA VIII (Bateman Pump Station)			
Collection Area	74.9	33° 32’ 00” 100° 15’ 00”	Located on the South Fork of the Wichita River.
AREA X (Lowrance Pump Station)			
Collection Area	19.7	33° 45’ 00” 100° 10’ 00”	Located on the Middle Fork of the Wichita River.
TRUSCOTT BRINE RESERVOIR			
Truscott Brine Dam	3.6	33° 47’ 52" 99° 50’ 11"	Bluff Creek, Knox County, Texas

2 WICHITA RIVER ONLY PORTION OF THE RRCCP ALTERNATIVES.

Action alternatives to lower chloride concentrations in the Wichita River, as addressed by this section, include continued operation of existing chloride control facilities and completion of facilities under construction. The first portion of this section provides an overview of the sources and means of addressing each source while the second portion discusses, in summary, each of the 27 alternatives. Complete discussions and analyses of each alternative are provided in the referenced documents. Finally, discussion is given to project conditions that would require future environmental review.

Existing chloride control features were addressed in Section 1. The remaining chloride control activities have been organized into 27 alternatives, including the No Action alternative. These alternatives address each source area's brine collection, transfer, and disposal.

a. Source Area Plans. The alternative plan for each source area consists of a collection system and a disposal system. The proposed source areas and stages of development include Area V (constructed), Area VII (not constructed), Area VIII (constructed), and Area X (partially constructed) as described in the 1976 FES. Disposal options analyzed included Truscott Brine Reservoir as well as USFWS/TPWD alternatives to dispose of brine in Beaver Creek, Paradise Creek, or Raggedy Creek in the Red River basin. A summary of the collection and disposal methods is provided below.

1. Collection Systems. One type of collection system was studied in detail: low-flow, deflatable, fabric dams. The low-flow dams would impound flows that would be drained into a sump and pumped to a disposal system. The dams would have a deflatable weir section that would allow flood flows to pass unimpeded. Collected brines would then be pumped to their disposal site using parallel vertical turbine pumps and an underground pipeline.

2. Disposal Systems. Four alternatives were considered for brine disposal:

(a) Brine Impoundment Reservoir. A brine impoundment reservoir would consist of an impervious dam to impound brine water and serve as an evaporation reservoir. Specifically, the constructed features of Truscott Brine Disposal Reservoir would be used with this disposal alternative.

(b) Deep Well Injection. Deep well injection would pump brine down wells drilled into geologic formations known to possess adequate porosity and permeability.

(c) Diversion to Freshwater Streams. The USFWS/TPWD proposed that collected brines be pumped to existing freshwater streams in a different drainage basin. Specifically, the alternatives evaluated would pump collected brine from the upper Wichita River drainage basin to Beaver Creek, Paradise Creek, or Raggedy Creek in the Red River watershed. These alternatives would convert freshwater streams to brine streams.

(d) Volume Reduction. Volume reduction could be used with any of the three previous methods to reduce the amount of brine to be disposed. The method of volume reduction evaluated in this document includes spray fields. Spray fields would be pressure-operated at the pipeline inlet or outlet and would accomplish an overall volume reduction of roughly 25% per spray field.

b. Alternative Scenarios. A total of 27 alternatives, including the No Action alternative, were evaluated as outlined in the following sections.

1. No Action. Indefinitely postponing construction of a chloride control system was considered. This is referred to as the No Action alternative. This alternative would eliminate any adverse social or environmental effects associated with construction and operation of additional control systems; however, it would also forego water quality improvements and resultant economic and social benefits that construction of the project would provide. The No Action alternative does not address the project's purpose and need, but does provide a baseline for evaluating the impacts of other alternatives. The No Action alternative is used to compare all conditions with and without implementing the other alternatives over a 100-year timeframe.

Under the No Action alternative, the remaining chloride control features would not be completed however; brush management would be implemented with or without the proposed project. Due to growing concern in the Wichita River Basin about the availability of water and its effect on economic growth and development, brush control has been evaluated by the State as a means to increase watershed yield. The goal is to restore large areas of brush to native grasses, but leave brush buffers and habitat corridors. The proposed brush control program is expected to provide a net increase in overall watershed yield recognized at Lake Kemp. The brush control program has currently been included in Texas Senate Bill 1 and the Region B (RRA) Water Plan. Implementation is expected to occur regardless of chloride control. The Reevaluation has used a brush management factor of 50% implementation (i.e. brush removal in 50% of the watershed) as its future condition (USACE 2001a).

2. USACE Action Alternatives. Fourteen alternatives were developed by the USACE for achieving lower concentrations of chlorides in the Wichita River. Detailed descriptions of the alternatives to the authorized plan were also included in Section 6 of the 1976 FES. This document is available for review at http://www.swt.usace.army.mil/LIBRARY/Library.CFM.

The objective of the 14 USACE action alternatives was to improve water quality in the Wichita River to a point where it may be economically useful for municipal, industrial, and agricultural water supply. A summary of the USACE action alternatives is provided in Table 2-1. Common elements among the original USACE action alternatives include:

- continued operation of the existing ring dike at Area V (Estelline Springs),
- continued operation of the existing Area VIII brine collection area,
- continued operation of the Area VIII pipeline to Truscott Brine Disposal Reservoir, and
- continued operation of the Truscott Brine Disposal Reservoir.

3. USFWS/TPWD Action Alternatives. The 12 alternatives developed by the USFWS with the TPWD are discussed in detail in the "USFWS/TPWD Chloride Control Concept Alternatives Reconnaissance Level Formulation and Evaluation Summary" (USACE 2001b). The objectives of the 12 USFWS/TPWD alternatives were to lower chloride control impacts by reducing brines pumped to Truscott and eliminating potential selenium impacts, as well as replacing stream habitat and lessening the impact of zero flow days on refugia fish populations. A summary of these alternatives is provided in Table 2-2. For the USFWS/TPWD alternatives, the alternative number for this Reevaluation is shown first. The alternative number in parentheses refers to alternative numbering in the "USFWS/TPWD Chloride Control Concept Alternatives Reconnaissance Level Formulation and Evaluation Summary" (USACE 2001b).

TABLE 2-1

USACE WICHITA RIVER PORTION OF THE RED RIVER CHLORIDE CONTROL PROJECT ALTERNATIVES

ALTERNATIVE NO.	ALTERNATIVE COMPONENTS
1	Construct low water dam collection facilities at Area VII. Deep well inject Area VII brine. Continue to pump Area VIII brine to Truscott Brine Reservoir (average 5.2 cfs). Deep well inject Area X brine collected from constructed facilities.
2	Construct low water dam collection facilities at Area VII. Deep well inject Area VII brine. Continue to pump Area VIII brine to Truscott Brine Reservoir (average 5.2 cfs). Pump Area X brine to Truscott Brine Reservoir. No changes to Truscott Brine Reservoir embankment.
3	Construct low water dam collection facilities at Area VII. Pump area brine to Truscott Brine Reservoir. Continue to pump Area VIII brine to Truscott Brine reservoir (average 5.2 cfs). Deep well inject Area X brine. Raise Truscott Brine Reservoir embankment by 17.2 feet for needed extra storage.
4	Construct low water dam collection facilities at Area VII. Deep well inject Area VII brine. Continue to pump Area VIII brine to Truscott Brine Reservoir (average 5.2 cfs). Indefinitely defer construction at Area X. No changes to Truscott Brine Reservoir embankment.
5	Construct low water dam collection facilities at Area VII. Pump Area VII brine to Truscott Brine Reservoir. Continue to pump Area VIII brine to Truscott Brine Reservoir (average 5.2 cfs). Pump Area X brine to Truscott Brine Reservoir. Raise Truscott Brine Reservoir embankment by 33.2 feet to account for needed extra storage.
6	Construct low water dam collection facilities at Area VII. Pump Area VII brine to Truscott Brine Reservoir. Continue to pump Area VIII brine to Truscott Brine Reservoir (average 5.2 cfs). Indefinitely defer construction at Area X. Raise Truscott Brine Reservoir embankment by 17.2 feet to account for needed extra storage.
7	Construct low water dam collection facilities at Area VII. Pump Area VII brine to Truscott Brine Reservoir. Continue to pump Area VIII brine to Truscott Brine Reservoir (average 5.2 cfs). Continue operation of the outfall spray field at Truscott Brine Reservoir assuming 25% flow reduction. Pump area X brine to Truscott Brine Reservoir. Raise Truscott Brine Reservoir embankment by 17.2 feet for needed extra storage.

Table 2-1 (Continued)

ALTERNATIVE	ALTERNATIVE COMPONENTS
7a	Construct low water dam collection facilities at Area VII. Pump Area VII brine to Truscott Brine Reservoir. Continue to pump Area VIII brine to Truscott Brine Reservoir. Construct pipeline from Area X to Truscott Brine Reservoir and pump Area X brine to Truscott Brine Reservoir. Construct spray fields at intake and outfall of each pipeline (Area VII, Area VIII (existing) and Area X). Potentially raise top of Truscott Brine Reservoir dam by 2.4 feet using a stemwall. (at a later date)
8	Construct low water dam collection facilities at Area VII. Pump Area VII brine to Truscott Brine Reservoir. Continue to pump Area VIII brine to Truscott Brine Reservoir (average 5.2 cfs). Continue operation of the Area VIII outfall spray field at Truscott Brine Reservoir assuming 25% flow reduction. Indefinitely defer construction at Area X. Raise top of Truscott Brine Reservoir dam by 2.4 feet using stemwall.
8a	Construct low water dam collection facilities at Area VII. Pump Area VII brine to Truscott Brine Reservoir. Construct spray fields at intake and outfall of each pipeline (Area VII, Area VIII (existing) and Area X). Continue pumping Area VIII brine to Truscott Brine Reservoir (flow to 6.2 cfs). Indefinitely defer construction at Area X. No changes to Truscott Brine Reservoir embankment.
9	Construct low water dam collection facilities at Area VII. Pump Area VII brine to Truscott Brine Reservoir. Continue pumping Area VIII brine to Truscott Brine Reservoir (flow to 5.7 cfs). Continue operation of the Area VIII outfall spray field at Truscott Brine Reservoir assuming 25% flow reduction. Indefinitely defer construction at Area X. Raise top of Truscott Brine Reservoir embankment by 4.4 feet for extra storage.
10	Construct low water dam collection facilities at Area VII. Pump Area VII brine to Truscott Brine Reservoir. Continue to pump Area VIII brine to Truscott Brine Reservoir (flow to 5.7 cfs). Continue operation of the Area VIII outfall spray field at Truscott Brine Reservoir assuming 25% flow reduction. Indefinitely defer construction at Area X. Raise top of Truscott Brine Reservoir dam by 4.4 feet for extra storage.
11	Construct low water dam collection facilities at Area VII. Pump Area VII brine to Truscott Brine Reservoir. Continue to pump Area VIII brine to Truscott Brine Reservoir (flow to 5.7 cfs). Indefinitely defer construction at Area X. Raise top of Truscott Brine Reservoir embankment by 19.2 feet for extra storage.
12	Indefinitely defer construction at Area VII. Continue to pump Area VIII brines to Truscott Brine Reservoir (flow to 5.7 cfs). Pump Area X to Truscott Brine Reservoir. No changes to Truscott Brine Reservoir embankment.

TABLE 2-2

USFWS/TPWD WICHITA RIVER PORTION OF THE RED RIVER CHLORIDE CONTROL PROJECT ALTERNATIVES

ALTERNATIVE NO.	ALTERNATIVE COMPONENTS
13 (4a1)	Construct low water dam collection facilities at Area VII. Construct pipeline and pump Area VII to Raggedy Creek. Continue to pump Area VIII brines to Truscott Brine Reservoir. Defer construction at Area X indefinitely.
14 (4a2)	Construct low water dam collection facilities at Area VII. Construct pipeline and pump Area VII to Paradise Creek. Continue to pump Area VIII brines to Truscott Brine Reservoir. Defer construction at Area X indefinitely.
15 (4a3)	Construct low water dam collection facilities at Area VII. Construct pipeline and pump Area VII to Beaver Creek. Continue to pump Area VIII brines to Truscott Brine Reservoir. Defer construction at Area X indefinitely.
16 (4b1)	Construct low water dam collection facilities at Area VII. Construct pipeline and pump Area VII brine to Raggedy Creek. Continue to pump Area VIII brine to Truscott Brine Reservoir. Construct pipeline and pump Area X brines to Raggedy Creek.
17 (4b2)	Construct low water dam collection facilities at Area VII. Construct pipeline and pump Area VII brine to Paradise Creek. Continue to pump Area VIII brine to Truscott Brine Reservoir. Construct pipeline and pump Area X brines to Paradise Creek.
18 (4b3)	Construct low water dam collection facilities at Area VII. Construct pipeline and pump Area VII brine to Beaver Creek. Continue to pump Area VIII brine to Truscott Brine Reservoir. Construct pipeline and pump Area X brines to Beaver Creek.
19 (4c1)	Construct low water dam collection facilities at Area VII. Construct pipeline and pump Area VII brine to Raggedy Creek. Construct new pipeline from Area VIII to Raggedy Creek. Abandon existing Area VIII pipeline to Truscott Reservoir. Defer construction at Area X indefinitely. Drain Truscott Brine Reservoir.
20 (4c2)	Construct low water dam collection facilities at Area VII. Construct pipeline and pump Area VII brine to Paradise Creek. Construct new pipeline from Area VIII to Paradise Creek. Abandon existing Area VIII pipeline to Truscott Reservoir. Defer construction at Area X indefinitely. Drain Truscott Brine Reservoir.

Table 2-2 (Continued)

ALTERNATIVE NO.	ALTERNATIVE COMPONENTS
21 (4c3)	Construct low water dam collection facilities at Area VII. Construct pipeline and pump Area VII brine to Beaver Creek. Construct new pipeline from Area VIII to Beaver Creek. Abandon existing Area VIII pipeline to Truscott Reservoir. Defer construction at Area X indefinitely. Drain Truscott Brine Reservoir.
22 (4d1)	Construct low water dam collection facilities at Area VII. Construct pipeline and pump Area VII brine to Raggedy Creek. Construct new pipeline and pump brines from Area VIII to Raggedy Creek. Abandon existing Area VIII pipeline to Truscott Reservoir. Construct new pipeline and pump brines from Area X to Raggedy Creek. Drain Truscott Brine Reservoir.
23 (4d2)	Construct low water dam collection facilities at Area VII. Construct pipeline and pump Area VII brine to Paradise Creek. Construct new pipeline and pump brines from Area VIII to Paradise Creek. Abandon existing Area VIII pipeline to Truscott Reservoir. Construct new pipeline and pump brines from Area X to Paradise Creek. Drain Truscott Brine Reservoir.
24 (4d3)	Construct low water dam collection facilities at Area VII. Construct pipeline and pump Area VII brine to Beaver Creek. Construct new pipeline and pump brines from Area VIII to Beaver Creek. Abandon existing Area VIII pipeline to Truscott Reservoir. Construct new pipeline and pump brines from Area X to Beaver Creek. Drain Truscott Brine Reservoir.

c. Alternative Analysis. The economic base condition used in evaluation of the alternatives was 2001. Completed features, including mitigation features, have been accounted for as sunk costs for the purpose of this Reevaluation. Sunk costs are costs that have already been incurred and therefore do not affect current decisions. A discussion of completed features (sunk costs) was presented in Section 1.

From the USFWS/TPWD alternatives, Number 13 (4a1) was identified as having the greatest economic potential. The BCR for this alternative was calculated to be 1.23 to 1. While this alternative is economically viable, net NED benefits for the alternative are less than the proposed plan. In addition, implementation issues, as described below, would potentially preclude this alternative from further consideration. These issues, which are common to all the USFWS/TPWD alternatives, include:

- Technical viability of proposed alternatives to create new salt-tolerant species habitat (i.e., can suitable new habitat be created in a short time period);
- Regulatory viability in light of potential TNRCC opposition to degradation of usable freshwater streams from brine and selenium introduction;
- Destruction of fresh water streams and riparian (wetland) habitat;
- Public and municipal objections to stream conversion;
- Land use and land value impacts to landowners, farmers, and ranchers from converting freshwater streams to brine streams;
- Flooding and erosion risks from increased stream flow.

From the USACE alternatives, Number 7a was selected as having the greatest net NED benefits. However, concerns regarding this alternative have been raised by the USFWS and TPWD including:

- Impacts to aquatic resources through reduced stream salinity and native fishes that are adapted and dependent on naturally high salinities;
- Selenium levels in Truscott Brine Reservoir and potential impacts to migratory birds;
- Security of water supplies for the Dundee State Fish Hatchery at Lake Diversion;
- Changes in water quality at the Dundee State Fish Hatchery and the potential for golden algae blooms;
- Potential impacts to sport fisheries at Lakes Kemp, Diversion and Texoma;
- Impacts to prairie stream ecosystems due to exacerbated low flow conditions and reduction in chloride loads; and
- Invasion of salt cedar or zebra mussels.

Due to higher economic, technical, and regulatory viability, Alternative No. 7a best serves the purpose and need for the proposed action. Consequently, Alternative No. 7a is the proposed plan.

The purpose and need for the chloride control project, as stated in Section 1, is to improve the quality of the Wichita River water resources to the extent that they would be usable for municipal, industrial, and agricultural purposes. The Wichita River system is ideally located to provide a supplemental water supply to a multi-county region of North Texas which is expected to collectively require an additional source supply by 2015. In addition, some communities have an immediate need for a supplemental source supply to accommodate present water supply shortages. In summary, supplemental water supplies are contingent upon improved water quality from chloride control measures. The other alternatives would not serve the purpose and need for the proposed action for one or more of the following reasons:

- They do not meet NED requirements.
- They do not provide substantial reduction of brine flows (chloride and TDS concentrations) to meet water quality standards consistently.
- They do not provide consistent water quality in a cost effective manner.
- They cannot be completed due to technical, regulatory, or other feasibility issues.

3 AFFECTED ENVIRONMENT

The purpose of this section is to describe areas potentially affected by the proposed project. The beginning of this section addresses general area-wide attributes while latter portions describe geographically specific conditions.

a. Study Area. The study area encompasses all of the Wichita River from the upstream brine collection facilities downstream to the Wichita River's confluence with the Red River and the upper Red River from its confluence with the Wichita River downstream to Lake Texoma. A map delineating the project study area and study reaches is shown in Figure 3-1. Hydrologic study reaches included Reach 11 (South Fork of the Wichita River), Reach 10 (North & Middle Fork of the Wichita River), Reach 9 (main stem Wichita River to Lake Diversion dam), Reach 8 (Wichita River from Lake Diversion dam to confluence with the Red River), Reach 7 (Red River at Cooke/Montague county line to Wichita River confluence), Reach 6 (Cooke/Montague county line to Lake Texoma), and Reach 5 (Lake Texoma). The study area also encompasses lands within 50 elevation feet of rivers and reservoirs within the study area as well as agricultural lands within each hydrologic region affected by potential changes in irrigation. The project area and scope constitutes a major change over the RRCCP in that several reaches previously evaluated have not been included in this study and would not be affected with implementation of the currently proposed project.

1. Physiographic and Climate Setting. The study area in north central Texas is approximately 250 miles north of the Gulf of Mexico. Elevation of the area's rolling hills range from 500 to 800 feet above sea level. The area lies within the Rolling Plains ecoregion. This region is characterized by a slightly undulating land surface dominated by native rangelands. The general setting of the study area is the Central Rolling Red Plains physiographic region of Texas.

The climate is humid-subtropical with hot summers. It is also continental, characterized by a wide annual temperature range. Precipitation also varies considerably, ranging from 18 inches to more than 36 inches. Throughout the year, rainfall occurs more frequently during the night. Usually, periods of rainy weather last for only a day or two and are followed by several days with fair skies. A large part of the annual precipitation results from thunderstorm activity, with occasional heavy rainfall over brief periods of time. Thunderstorms occur throughout the year, but are most frequent in the spring. Hail falls on about 2 or 3 days a year, ordinarily with only slight and scattered damage. Windstorms occurring during thunderstorm activity are sometimes destructive. Snowfall is rare.

Winters are mild but "blue northers" occur about three times each winter month. Precipitous drops in temperature typically accompany these events. Periods of extreme cold occasionally occur but are short-lived so that even in January mild weather frequently occurs.

The highest temperatures of summer are associated with fair skies, westerly winds, and low humidity. Characteristically, hot spells in summer are broken into three-to-five day periods by thunderstorm activity except during El-Niño years. There are only a few nights each summer when the low temperature exceeds 80 °F. Summer daytime temperatures frequently exceed 100 °F. Average low and high temperatures range from 37 °F in January to 98 °F in August.

The average length of the warm seasons (freeze-free period) is about 249 days, or about 6 months. The average last occurrence of 32 °F or below is mid-March, and the average first occurrence of 32 °F or below is in late November.

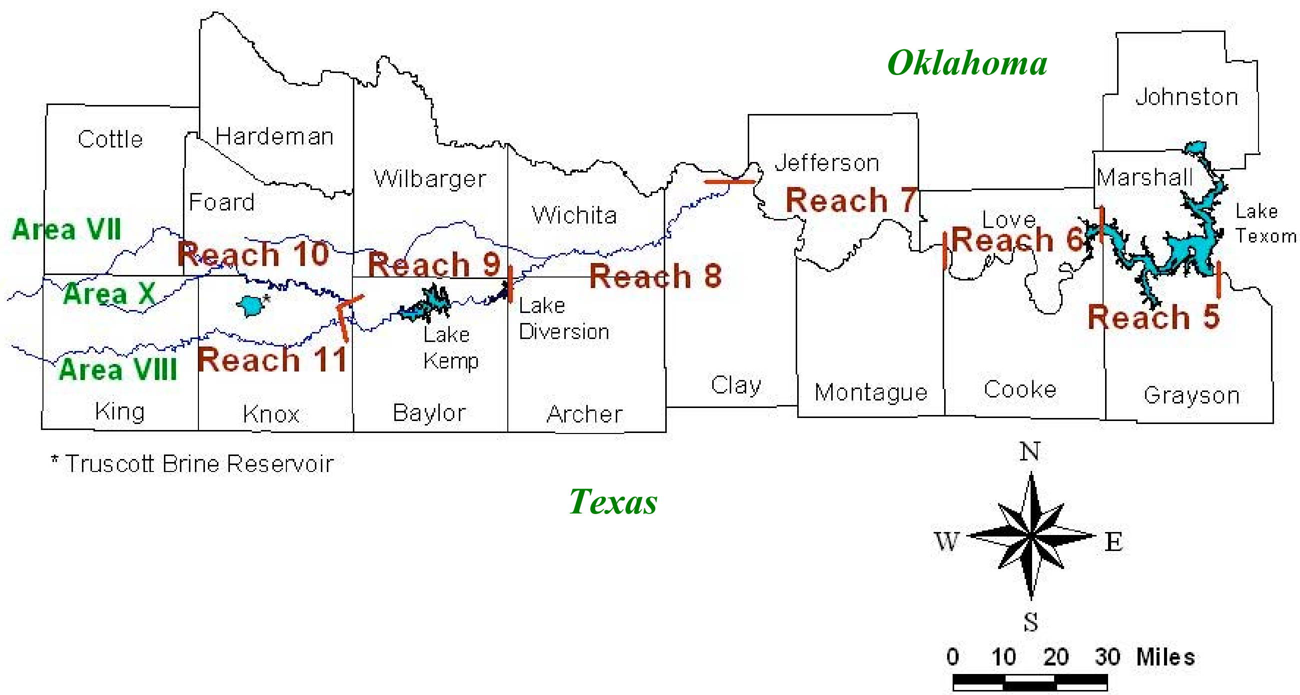
2. Vegetation. Vegetative communities occurring within the study area are predominantly a function of human influence. Existing vegetative communities throughout the entire basin include a number of different types composed of various sub-climax stages. True climax communities are largely absent throughout this area having been modified by cultivation, fire control, and grazing. Agriculture is the principal land use throughout the study area. Native floodplain vegetation largely has been cleared or fragmented into small, isolated patches and replaced with tame pasture, hay, vegetables, and small grains. Although highly impacted by human activity, remnant habitats still provide essential life requisites for aquatic and terrestrial life. The Wichita River Basin is dominated by rangeland used primarily for grazing cattle. Most of the study area watershed is a mixture of juniper and mesquite shrubs and grassland, with some areas of cropland. The riparian community is relatively narrow in most of the watershed and consists largely of saltcedar (*Tamarix chinensis*), willow (*Salix spp.)* and some cottonwood (*Populus deltoides)*.

3. Soils. The proposed plan features would be located in north central Texas in a region dominated by Permian Age sedimentary rocks. The project lies near the southwestern edge of the Osage Plains section of the Central Lowlands Physiographic Province and adjacent to the High Plains Physiographic Province to the west. The project sites are underlain by the relatively flat lying Permian age Flowerpot Shale and Blaine Formations. Flowerpot Shale is a thick unit of impervious red-bed shales, interbedded with thin green-gray shales and, in the upper part of the formation, with bed of gypsum and dolomite. The overlying Blaine formation consists of interbedded gypsum, dolomite, and shale. With the exception of low-lying drainage areas, bedrock consisting of the above-described units is exposed or is anticipated to be present at shallow depths across most of the upland surfaces.

Soils in the proposed project area consist primarily of colluvial deposits on the upland areas and sidehill slopes. These deposits consist primarily of silt and clay with varying amounts of bedrock float fragments and are interpreted to be the product of weathering of the underlying bedrock. These deposits range in depth from zero feet, where bedrock is exposed on the surface, to a depth of several feet, generally near the base of slopes. Alluvial deposits are present in the drainage areas. The deposits are generally in the form of flat surfaced terraces. In some of the larger drainage areas, two levels of terraces are present – low narrow terrace adjacent to the active stream channel and a higher level terrace beyond. The thickness of the deposits are thinnest near the margins of the drainage and adjacent to the steeper slopes and range from 10 to 20 feet in thickness near the drainage. These deposits generally consist of an upper portion of sandy, silty clay underlain by coarse grain sediments consisting of silt, sand and gravel with occasional cobbles. Features of the proposed plan are located in these shallow soil areas.

4. Air Quality. A non-attainment area is an area which does not meet one or more of the National Ambient Air Quality Standards (NAAQS) for criteria pollutants listed in the Clean Air Act (CAA). Information from the TNRCC indicates that the project is not located in a non-attainment area.

FIGURE 3-1
HYDROLOGIC REACHES FOR THE PROPOSED PROJECT



5. Wild and Scenic Rivers. In the 1960's, there was a growing awareness that our nation's rivers were being dammed, dredged, diverted, and polluted at an alarming rate. In 1968, Congress passed the Wild and Scenic Rivers Act, requiring it to be the policy of the United States that *"certain selected rivers of the Nation which, with their immediate environments, possess outstandingly remarkable scenic, recreational, geologic, fish and wildlife, historic, cultural or other similar values, shall be preserved in free-flowing condition, and that they and their immediate environments shall be protected for the benefit and enjoyment of present and future generations."*

The act established three classes of river areas: 1) Wild river areas**,** characterized as being unpolluted, free from impoundments, generally inaccessible except by trail, with primitive watersheds or shorelines; 2) Scenic river areas, characterized as being free from impoundments, generally accessible in places by road, and having shorelines or watersheds still largely undeveloped; and 3) Recreational river areas**,** which may include some development along their shoreline, readily accessible by road or railroad, and may have undergone some impoundment or diversion in the past. Rivers that may be impacted by the proposed plan include the Wichita River and the Red River.

6. Environmental Justice. Environmental justice has been defined as the pursuit of equal justice and equal protection under the law for all environmental statutes and regulations without discrimination based on race, ethnicity, or socioeconomic status. There are three categories of environmental equity issues: Procedural inequity, geographical inequity, and social inequity (Bullard 1993). Procedural inequity addresses questions of fair treatment: the extent that governing rules, regulations, and evaluation criteria are applied uniformly. Geographical inequity refers to areas receiving direct benefits, such as jobs and tax revenues, from industrial production while the costs, such as the burdens of waste disposal, are sent elsewhere. Social inequity refers to the concept that environmental decisions often mirror the power arrangements of larger society and reflect existing racial biases. Finally, providing environmental justice goes beyond the stated definition and includes a guarantee of equal access to relief and meaningful community participation with government and industry decision-makers. With respect to the proposed plan, one localized brine disposal reservoir would be used while benefits would be distributed throughout the Wichita River basin.

7. Threatened and/or Endangered Species. By letter dated March 5, 1999, the USFWS identified the Federally listed species likely to be affected by the proposed project. They include the whooping crane (*Grus americana*), the bald eagle (*Haliaeetus leucocephalus*), and the interior least tern (*Sterna antillarum*), which are the same species addressed in the previous formal consultation and the 1994 USFWS Biological Opinion (BO). These species and their status can be found in Table 3-1.

A Biological Assessment (BA) for the Wichita River Basin was performed by the USACE in May 2001. This BA included revised data for the project area. Specifically, the USACE conducted avian monitoring at Truscott Brine Disposal Reservoir to address potential Se impacts. The USACE also recalculated flow and chloride concentration data for the Wichita River hydrologic reaches. Information from the 2001 BA is included in this document.

The whooping crane is a migrant through central Oklahoma and Texas during the fall and spring. Recorded sightings confirm this species' presence during migration in the general area. Sightings have been confirmed from the extreme eastern portion of Texas. Six sightings were from Clay County near Byers, Texas, and the other was from Wichita County near the city of Electra, Texas. Most of the recorded sightings for this species are in relation to the Great Salt Plains Reservoir in north central Oklahoma and the Washita National Wildlife Refuge in southwestern Oklahoma. The Great Salt Plains is recognized as an important whooping crane migration stopover area and supports from 1 to 12 birds during migration periods. Additional bird surveys conducted during the fall and/or spring of 1997-1999 at Truscott Brine Disposal Reservoir and the Area VIII collection facility resulted in no sightings of whooping cranes (USACE 2001d).

The interior least tern occurs along major rivers in Oklahoma and Texas as a summer, breeding resident (S2B – 6 to 20 occurrences within the State, very vulnerable to extinction throughout its range) and migrant. They occur in association with riverine habitats primarily on unvegetated sandbars and shorelines. A review of available literature suggests that this species occurs as a migrant within the general project area. On May 22-24, 1991, personnel from the USACE conducted a survey for the interior least tern at the Area X collection facility and Truscott Brine Disposal Reservoir. No least terns were sighted in the noted areas, and most of the areas appeared to be void of habitat typically suited for this species (USACE 2001d). The interior least tern has been observed at the Truscott Brine Disposal Reservoir more recently. Texas Tech University personnel found the least tern at Truscott Brine Disposal Reservoir during the spring and fall migrations. However, no least tern nests or nesting was observed at the lake during their bird counts conducted in the spring and winter of 1997, 1998, and January 1999 (USACE 2001d).

The bald eagle is a winter migrant throughout the State of Oklahoma and a winter resident along major rivers and impoundments. The total winter population in the study area is unknown, but eagles are likely present along the 140-mile stretch of the Red River from Lake Texoma to the Red River's confluence with the Wichita River Data provided by the USFWS in the previous BO place the wintering population of eagles in Oklahoma between 516 and 1,167. Estimates of eagle use on the Red River are difficult to obtain because few surveys are made of this remote area. Annual midwinter surveys at Lake Texoma and Waurika Lake indicate that eagles use the upper Red River. From 1984-1992, bird numbers averaged 54.5 at Lake Texoma and 4.9 at Waurika Lake. No bald eagles were sighted during the intensive bird count surveys completed from 1977-1999 at Truscott Brine Disposal Reservoir and the Area VIII collection facilities (USACE 2001d). The USFWS has determined that this species has recovered to the point that it should be removed from the list of threatened and endangered species. The bald eagle is currently listed as Threatened, although it is proposed for delisting. However, the delisting process has not been completed, and the bald eagle currently remains on the list.

State listed species have no legal protection under the Endangered Species Act, as amended, and have been included within this document for planning purposes only. Several State of Oklahoma listed species have been identified as possibly occurring in the project area (Table 3-1). These include the Texas kangaroo rat (*Dipodomys elator*), which inhabits the mesquite grasslands on clay soils in the project area; the Snowy plover (*Charadrius alexanderinus*), whose range encompasses the upper portions of the project area; the Texas horned lizard (*Phrynosoma cornutum*), the blacksided darter (*Percina maculata*), and the shovelnose sturgeon (*Scaphirhynchus platorhynchus*), which all occur within the study area.

TABLE 3-1

STATE AND FEDERALLY LISTED SPECIES FOR THE PROPOSED PROJECT

Scientific Name	Common Name	Federal Status	Oklahoma State Status	Texas State Status
Mammals				
Dipodomys elator	Texas kangaroo rat		SS2	T
Birds				
Charadrius alexanderinus	Snowy plover		SS2	
Grus americana	Whooping Crane	E	E	E
Haliaeetus leucocephalus	Bald Eagle	T	T	T
Sterna antillarum	Interior Least Tern	E	E	E
Reptiles				
Crotalus horridus	Timber rattlesnake			T
Phrynosoma cornutum	Texas horned lizard		CS, SS2	T
Fish				
Cycleptus elongates	Blue sucker			T
Percina maculata	Blacksided darter		T	T
Polydon spathula	Paddlefish			T
Scaphirhychus platorhynchus	Shovelnose sturgeon		SS2	T

Federal Status
E - Endangered
T - Threatened
C - Candidate Taxa
SC - Species of Concern: Those species with insufficient data to make a decision regarding status.

Oklahoma State Status
E - Endangered
T - Threatened
SN – State nominated for listing as T or E
SS1 – Species of Special Concern that current evidence indicates especially vulnerable
SS2 – Species of Special Concern that have been identified by experts as possibly threatened or extirpated
CS – Statewide closed season

Texas State Status
E – Endangered
T – Threatened

A search of the Texas Natural Heritage Program's database revealed several State of Texas listed species that may occur within the project area (Table 3-1). These include the Texas kangaroo rat, the Texas horned lizard, the timber rattlesnake (*Crotalus horridus*), the blue sucker (*Cycleptus elongates*), the blacksided darter, the paddlefish (*Polydon spathula*) and the shovelnose sturgeon.

8. Cultural Historic Setting. The portion of northern Texas where the proposed project area is located generally falls within the Southern Great Plains culture area (Brooks and Hofman 1989, Wyckoff and Brooks 1983), although the project area falls within several different regions. The 1954 overview of Texas archeology by Suhm, Krieger, and Jelks placed the project area on the western edge of their north-central Texas regions (Suhm *et al.* 1954). In 1981, Lynott placed this area in what he called northern Texas, which included everything between the High Plains and east Texas and everything north of the Edwards Plateau (Lynott 1981). In its designation of archeological regions in Texas for comprehensive planning, the Texas Historical Commission (THC) placed the project area near the center of its Lower Plains region, falling between the High Plains, central Texas, and north-central Texas (Biesaart *et al.* 1985). Although unique in some respects, the Lower Plains area has strong similarities to the surrounding areas in both natural and cultural features (Wyckoff and Brooks 1983).

The general setting of the project area is the Central Rolling Red Plains physiographic region of Texas, which has been subjected to only minimal cultural resources investigations. Cultural chronologies based on investigations in the surrounding areas are often used to characterize the Central Rolling Red Plains. A cultural chronology for the region was developed during investigations for the RRCCP and is presented in Table 3-2. An extensive discussion of the stages presented in this chronology is presented in Schreyer *et al.* (2001) and is incorporated herein by reference.

(a) Area VII Collection Area and Pipeline Corridor. A total of six prehistoric sites dating to the Archaic period were found within the vicinity of Area VII during a preliminary cultural resource reconnaissance survey (Hughes 1972). All six sites were located within the proposed Y-Ranch low-flow dam project area along the North Fork of the Wichita River (Hughes 1972:2-30, 2-32 and V-18). One site was classified as a camp dating to the Archaic period (Hughes 1972: V-5), three were classified as camp-quarry stations, and the remaining site was classified as a quarry station.

(b) Area X Pipeline Corridor. Late in 1994, the proposed pipeline corridor connecting the Area X collection area and Truscott Brine Disposal Reservoir was inventoried for cultural resources, and two sites were identified within the corridor (Largent *et al.* 1995).

TABLE 3-2
CULTURAL CHRONOLOGY FOR THE SOUTHERN GREAT PLAINS AND LOWER PLAINS OF TEXAS

Cultural Stage	Approximate Date Range
Paleo-Indian	
Pre-Clovis?	Prior to 9,800 B.C.
Clovis	9,800-8,900 B.C
Folsom	8,900-8,200 B.C.
Late Plaeo-Indian	8,200-6,500 B.C
Archaic	
Early	6,000-3,000 B.C.
Middle	3,000-1,000 B.C
Late	1,000 B.C. – A.D. 1
Formative (Plains Woodland)	
Terminal Archaic/Late Prehistoric I	A.D. 1 – 800
Florescent (Plains Village)	
Late Prehistoric I	A.D. 800 – 1250
Late Prehistoric II	A.D. 1250 – 1450
Protohistoric/Early Historic	A.D. 1541 – 1875
Euro-American	A.D. 1875 – present

Source: Largent *et al.* 1995

(c) Area VII Pipeline Corridor. A cultural resources inventory of the proposed pipeline route between Truscott Brine Disposal Reservoir, Area VII, and the area surrounding the Truscott Brine Disposal Reservoir was performed in 2001 (Schreyer *et al.* 2001). A complete intensive survey of the area around the Truscott Brine Disposal Reservoir that would be impacted by an elevation of the lake level was also performed. Several limitations to this survey exist. Although field personnel walked over virtually the entire pipeline corridor, there was a 4.3-km section of the line that was difficult to access and not viewed in its entirety. Only high probability areas, based on proximity to drainages, were shovel tested. The line was not staked in the field and realignments during final engineering are likely. Nevertheless, the authors of the report believe that the level of sampling will provide a good basis for planning on the numbers and types of resources that exist within the final alignment. The inventory did result in the documentation of four prehistoric archeological sites that will require testing to reach a determination of eligibility for the National Register of Historic Places (NRHP) and seven prehistoric archeological sites and one historic farmstead that have been recommended to be not eligible for the NRHP.

(d) Area VIII Spray Field. The exact location for this spray field has not been identified. Once the location is known, and prior to construction, the area should be inventoried for cultural resources. If any resources were discovered in this area, in consultation with the THC they would be evaluated and impacts to them assessed.

(e) Chloride Control Projects. A Programmatic Memorandum of Agreement (PA) will be developed among the interested parties specifying which sites may be subject to unwanted effects and what actions should be taken to avoid or minimize those unwanted effects. This PA may also address the development of a Cultural Resources Management Plan for those cultural resources that are located on lands around Truscott Brine Disposal Reservoir that will not be affected by changes at the reservoir

9. Land Use. Land use was evaluated for each of the brine collection areas and the brine disposal site to be used under the proposed plan.

(a) Area VII. Current land use associated with the proposed collection facilities at Area VII consists primarily of rough, broken lands and mesquite and juniper grasslands utilized for grazing. Land use at Area VII has not changed since the original FES. Changes under the proposed plan would include installation of a 24-acre spray field in riparian habitat adjacent to the stream as well as installation of an inflatable dam, collection facilities, pump station, electrical power supply lines and pipeline conveyance to Truscott Brine Disposal Reservoir.

(b) Area VIII. Current land use associated with the collection facilities at Area VIII consists primarily of rough, broken lands and mesquite grasslands utilized for grazing alongside already constructed collection facilities. Land use at Area VIII has changed since the original FES as a specially authorized segment under the Flood Control Act of 1966, Public Law 89-789, and the Water Resources Act of 1976 for water quality control. Area VIII, with the exception of one spray field, is fully developed with respect to the proposed plan through these authorized projects. Facilities include an inflatable dam, collection structures, pump station, electrical pump station supply lines, and pipeline from Area VIII to Truscott Brine Disposal Reservoir. Additional structures proposed for Area VIII under the proposed plan include a 37-acre spray field in riparian habitat adjacent to the stream to reduce brine volume before pumping to Truscott Brine Reservoir.

(c) Area X. Area X is currently partially developed with respect to the proposed project. Previously constructed facilities at the site include an inflatable dam and pump station. Additional facilities that would be added by construction of the proposed plan would be a 32-acre spray field located in riparian habitat adjacent to the stream as well as electrical power supply lines and pipeline conveyance to Truscott Brine Disposal Reservoir. The surrounding area is currently used as cattle rangeland with a dirt road leading into the site.

(d) Truscott Brine Disposal Reservoir. Truscott Brine Disposal Reservoir currently receives brine from Area VIII, and with the proposed plan would also receive brines from Areas VII and X. Land use at Truscott Brine Disposal Reservoir has changed since the original FES in 1977 as a result of being a specially authorized segment of the Flood Control Act of 1966, Public Law 89-789, and the Water Resources Act of 1976 for water quality control. Truscott was completed in 1982 and has been collecting brines from Area VIII since 1987. The lake currently has a pool of approximately 1,700 surface acres.

Vegetation communities that were present within pool limits of Truscott Brine Disposal Reservoir are being covered by the brine pool. They are gradually being inundated with brine from the Area VIII pumping facility and would begin disappearing at an accelerated rate as other pumping facilities become operational. An evaporation spray field for Area VIII brine pipeline discharge has been installed to concentrate brine and reduce volumes prior to discharge into the reservoir. Additional facilities that would be added by the proposed plan include a 28-acre spray field for Area VII brine.

10. Environmental End Use by Reach. This Reevaluation used the economic reaches shown in Figure 4-1. Studies by Texas A&M University (2000) show a decrease in agricultural land use from 1977 to 1987, then an increase from 1987 to 1997 for an overall increase during the 20-year study period. National Agricultural Statistics Service (NASS) agriculture data show a similar trend in major agriculture crops for the same time period. However, overall land use in the study area has changed minimally since the 1976 FES.

Landsat imagery, 1997 aerial photography, and Natural Resources Conservation Service (NRCS) coordination were used to evaluate specific crop usage for areas serviced by irrigation from the Wichita and Red rivers in the study area. The areas served by river irrigation were limited to those within 50 feet of elevation above the rivers, the estimated extent of irrigation head capacity. This study was conducted by Texas A&M University and the Texas Agricultural Experiment Station. The primary reaches showing agricultural development were Economic Reaches 6, 7, and 9. The results of this analysis for May 1997 are shown in Table 3-3.

TABLE 3-3
MAY 1997 AGRICULTURAL DEVELOPMENT
BY ECONOMIC REACH IN ACRES

Crop (May 1997)	Reach 6	Reach 7	Reach 9	Total
Winter Wheat	48,683	30,624	15,971	95,278
Grassland	118,641	56,418	93,804	268,862
Bare Agriculture/Harvested Wheat	18,617	8,775	37,274	64,666

Source: Srinivasan *et. al.* 2000

Additional evaluations for the same year were also conducted in October. The results of agricultural land use for the October analysis is shown in Table 3-4.

TABLE 3-4
OCTOBER 1997 AGRICULTURAL DEVELOPMENT
BY ECONOMIC REACH IN ACRES

Crop (October 1997)	Reach 6	Reach 7	Reach 9	Total
Cotton	4,124	2,920	3,871	10,916
Winter Wheat	20,746	10,607	14,463	45,816
Unknown/Failed Cotton	9,909	9,236	18,199	37,346
Bare Agriculture/Grain Sorghum	43,124	31,135	43,476	117,735

Source: Srinivasan *et. al.* 2000

Land use in the region above Lake Texoma is devoted mainly to agriculture and consists of farming and cattle ranching. On a county-wide basis, the area is predominantly dryland crops and pastureland. For the nine Texas and eight Oklahoma counties in the region, about 6 million acres were pastureland, 4 million acres dry land cropland, and 160,000 acres irrigated cropland in 1996. While about 59% of agricultural land use is pasture, only about 4% of the cropland is irrigated. For the most part, land use in the proposed project area is essentially the same as reported in the 1976 FES.

11. Socioeconomic Setting. The area adjoining the proposed project facilities is composed of parts of eleven counties in Texas (Cottle, Foard, Wilbarger, Wichita, King, Knox, Baylor, Archer, Clay, Cooke, and Grayson) and three counties in Oklahoma (Love, Marshall, and Bryan) and is populated mostly with people living in towns of less than 10,000. Based on U.S. Bureau of Census population data, 383,935 persons lived in the area in 2000. The number of persons living in the area increased by an average of five percent between 1990 and 2000.

The immediate study area covers parts of seven counties (Cottle, Foard, King, Knox, Baylor, Cooke, and Grayson) in Texas and three counties in Oklahoma (Love, Marshall, and Bryan), including the Wichita Falls, Texas, metropolitan area. The 2000 Census data indicated that 104,197 persons lived in the Wichita Falls area, and 217,735 people lived in the ten county area. The number of persons living in the ten county area increased by an average of four percent between 1990 and 2000.

12. Hazardous, Toxic, and Radiological Waste (HTRW). An assessment of the potential for encountering HTRW on all lands associated with the proposed plan was conducted by the USACE. Assessment methods included aerial site surveys for most parcels, interviews with local authorities, interviews with contract personnel working in the area, and interviews with regulatory agency personnel combined with a review of files maintained by these agencies. Visual site surveys included a search for any visual evidence of past HTRW storage or release (e.g. abnormal soil staining, drums or chemical containers, above ground tanks, lagoons, landfills). Agency files and databases were likewise searched for reported spills or potential problem areas.

Lands associated with the proposed plan can generally be described as very remote and historically undeveloped. While land access is available to limited portions of these areas via farm and ranch roads, many of the tracts possess few roads or other means of easy land access. Accordingly, land use in these areas has been limited to ranching and cattle grazing. Development has been minimal in the area, minimizing the potential for HRTW-related concerns.

Regulatory agency personnel reported no knowledge of any historical spills or areas of potential contamination in the project area.

b. Wichita River Basin.

1. Geographic Location and Basin Boundary. The Wichita River is a south bank tributary of the Red River at about river mile 907 and as such is part of the Red River watershed. The long, narrow Wichita River Basin drains a subhumid area of 2,485 square miles in north central Texas. The Wichita River is formed by the North, Middle, and South Forks, which originate in rolling hills and proceed easterly into the rolling prairie lands of north central Texas. These streams develop from small intermittent gullies in the upper reaches to well-defined streams with narrow, high bank floodplains bordered by high bluffs in the lower reaches of the study area. The geographic boundary of the study area for the Wichita River encompasses all of the Wichita River Basin from the collection areas downstream to the Wichita River's confluence with the Red River. The study area also encompasses lands within 50 elevation feet of the Wichita River (riparian habitat) as well as agricultural lands within each hydrologic region affected by potential changes in irrigation.

2. Chloride Sources. Assessment of chloride source areas since 1957 has identified two major types of chloride contributions to the Wichita River: oil field brines and natural chloride seeps or springs.

(a) Oil Field Brines. The principal man-made sources of chloride in the study area have been identified as originating from oil field brine disposal operations and stormwater runoff. The production of oil and/or gas commonly includes chlorides, often referred to as oil field brine, as a byproduct which requires proper disposal. Previous brine disposal practices from the early 1900's through the 1960's were by discharge into open earthen evaporation pits or the nearest watercourse. This method continued as an acceptable practice by many independent oil operators until regulations prohibited the disposal of brine in open pits. The chloride concentration of disposed brines typically ranged from 3,000 mg/l to as high as 35,000 mg/l.

Reduction of these sources has not been included as a goal of the proposed project. However, recognizing the impact to the environment and both surface and groundwater supplies, the State of Texas, acting through the Texas Railroad Commission, promulgated regulations (State-wide No Pit Order) that resulted in the emptying and backfilling of brine disposal pits, and required that the brine be injected into authorized zones as the only accepted means of disposal.

Since 1980, the majority of oil field brine produced is being disposed of by injection wells into formations from which it originated or is used in secondary oil recovery operations to increase production of partially depleted oil fields. Since 1996, about 85% of brine produced has been properly disposed of into permitted formations. However, residual chlorides contained in soils and alluvium deposits near previously abandoned disposal sites continue to permeate the basin's surface and groundwater resources. While there has been significant improvement in oil field operations to prevent oil field brine discharges, there continues to be considerable concern about the long-term impact of earlier practices and new contamination caused by occasional spills, which tend to originate from improperly plugged or abandoned wells, equipment malfunctions, and commingling of salt-bearing and freshwater aquifers.

Other man-made sources of chlorides entering the river system stem from municipal and industrial waste discharges. Since the 1970s, in response to the Federal Clean Water Act, the State of Texas has continued to force municipal and industrial waste dischargers to meet higher water quality standards with each new permit. Although chlorides are not normally a regulated parameter in waste discharge permits, advanced treatment techniques used to meet permitted parameters in conjunction with requirements to meet higher water quality stream standards have had, and will continue to have, a declining effect on chloride loads into the river system.

(b) Natural Chloride Sources and Associated Water Quality. Natural chloride areas occurring as seeps, springs, and salt flats are located in the basin study area. The sources identified for control in the proposed plan contribute about 551 tons/day of chlorides to the Wichita River. The Wichita River Basin is representative of several major river basins in the southwestern United States in regard to natural salt concentrations. Geologic formations underlying portions of Texas, Oklahoma, New Mexico, Kansas, and Colorado are sources of salt emissions to the rivers. In the past, this region was covered by a shallow inland sea. The salt-bearing geologic formations were formed by salts precipitated from evaporating sea water. Salt springs and seeps and salt flats in upstream areas of the basins now contribute large salt loads to the rivers. Chloride loads at each of the source areas are shown in Table 3-5.

Springs are natural groundwater seeps or flows, formed where underground water intercepts a low permeability material, such as rock or clay. Instead of filtering down, water moves horizontally, much like rain running off the roof of a house. This horizontal pooling of water forms the water table. In the project area, the water table typically follows surface topography. Springs, ponds, lakes, and streams mark places where the surface intercepts the water table. Salt seeps and springs are formed as the water table dissolves salt present in geologic formations as it flows.

TABLE 3-5
CHLORIDE LOADS BY SOURCE AREA

Salt Source Area	Contributing Stream	Natural Chloride Load (tons per day)
V[1]	Estelline Springs, Prairie Dog Town Fork	60
VII	North Fork, Wichita River	244
VIII[2]	South Fork, Wichita River	189
X[3]	Middle Fork, Wichita River	58
Total Identified Natural Sources		551

Source: USACE 2001a
[1] Ring dike (operational since January 1964) controls 240 of the total 300 tons per day of chlorides.
[2] Operating since 1987.
[3] Partially completed, not operational.

Area VII is the designation given to the chloride-contributing portion of the North Fork of the Wichita River and Salt Creek, a tributary of the North Fork. The majority of surface flow, under normal conditions is approximately 5 to 6 cubic feet/second (cfs), with chloride loading coming from several springs in Salt Creek. The chloride concentration from one spring in Salt Creek has measured as high as 17,000 mg/l. As a result, Area VII is emitting approximately 244 tons of chlorides per day.

Area X, on the Middle Fork of the Wichita River in northeastern King County, consists of three major salt springs approximately 11 miles from the mouth of the river. Springs in the source area are producing chloride concentrations from just over 3,000 to 6,200 mg/l. Mean flow and chloride loading for the river near the source area are 8.6 cfs and 58 tons/day, respectively.

Area VIII springs contribute almost 189 tons of salt daily to the South Fork of the Wichita River. A low-flow dam has been constructed at this location which traps 85% of the brine. The brine is pumped to Truscott Brine Disposal Reservoir. The result is that 160 tons of salt are removed from the South Fork of the Wichita River daily by the constructed facilities at Area VIII.

3. Wichita River Water Quality. Water quality measurements have been made for the North, Middle, and South Forks of the Wichita River. Data presented here included both single points and modeled estimates based on three decades of data. In addition, data have been obtained for naturally occurring Se concentrations as well as anthropogenic biochemical constituents.

(a) Naturally Occurring Salt Concentrations. Flows from Areas VII and X are combined where the Middle Fork of the Wichita River joins the lower North Fork of the Wichita River. A U.S. Geological Survey (USGS) gaging station on the lower North Fork of the Wichita River is located near Truscott. This gage is approximately 9 miles downstream from the confluence with the Middle Fork of the Wichita River. The drainage area at this point is over 937 square miles. Statistical data from Hydrologic Reach 10, the North Fork of the Wichita River, Truscott Gage, indicates overall chloride concentrations of 4,965 mg/l, sulfates of 2,284 mg/l, and TDS of 11,455 mg/l, 50% of the time (USACE 2001a). For comparison, the TDS of seawater is approximately 42,000 mg/l.

Single point water quality data for the North and Middle Forks of the Wichita River is presented in Table 3-6 for low and high flow conditions.

TABLE 3-6
WATER QUALITY IN THE NORTH AND MIDDLE FORKS OF THE WICHITA RIVER (REACH 10)

River Section	Gage	Watershed (sq-mi)	Date	Flow (cfs)	Specific Conductance (µS/cm)	TDS (mg/l)	Chloride Conc. (mg/l)
North Fork	Paducah	540	1/24/95	13	20,900	13,100	5,900
North Fork	Paducah	540	6/16/95	31	15,600	9,900	4,200
Middle Fork	Guthrie	NA	1/24/95	4.4	13,400	8,780	3,300
Middle Fork	Guthrie	NA	8/16/95	8.4	11,500	7,780	2,900
Main Stem	Truscott	937	2/7/95	22	17,300	11,900	5,200
Main Stem	Truscott	937	8/15/95	80	9,260	6,200	2,100

Source: USACE 2001a

A USGS gaging station is located on the South Fork of the Wichita River in Knox County, Texas. This gaging station is downstream from Area VIII. Statistical data from Hydrologic Reach 11, the South Fork of the Wichita River, Benjamin Gage, indicates chloride concentrations of 7,437 mg/l, sulfates of 2,710 mg/l, and TDS of 16,025 mg/l, 50% of the time (USACE 2001a).

Downstream, near Lake Kemp, overall water quality has been assessed. Statistical data from Hydrologic Reach 9, the main stem of the Wichita River, indicates chloride concentrations of 1,312 mg/l, sulfates of 755 mg/l, and TDS of 3,254 mg/l, 50% of the time (USACE, 2001b).

(b) Selenium. Elevated concentrations of Se occur naturally in surface waters of the general proposed project area. While natural background concentrations of Se in freshwater environments are typically less than 0.2 micrograms per liter (µg/l) or parts per billion (ppb) (Skorupa *et al.* 1996), concentrations appear to be much higher in the Wichita River Basin. For example, detected total Se concentrations in samples collected by the USGS range from 3 to 17 and 4 to 17 mg/l on the North Fork (Area VII), and Middle Fork (Area X) of the Wichita River, respectively (USACE 2000a). The upper end of the naturally-occurring range exceeds concentrations reported as hazardous to health and long-term survival of fish and wildlife populations (Lemly 1993, 1995).

(c) Anthropogenic Influences. Human populations living in north central Texas extensively use the Wichita River. Uses include municipal and industrial water supply, recreation, flood control, wastewater disposal, agricultural activities, and petroleum exploration and production. Table 3-7 lists maximum permitted water discharges and major impoundments for the Wichita River Basin portion of the study area. Reaches of the river with no permitted wastewater discharges reflect the lack of human population. Though not required to have wastewater discharge permits, other activities such as agriculture, oil and gas exploration and production potentially impact water quality in the basin. Human activities, such as clearing and overgrazing, have erased much of the original native grasslands and allowed mesquite and juniper introduction to expand. Mesquite introduction in turn affects water quality and quantity by decreasing runoff. The brush management program, as detailed in other sections, attempts to restore some vegetational components of the basin to pre-settlement conditions.

According to the TNRCC 1996 Summary of River Basin Assessments, water quality screening data for the Wichita River indicates possible concerns for nutrients, fecal coliform bacteria, dissolved metals, and dissolved minerals. The minerals (salts) come primarily from springs in the upper reaches of the basin and are concentrated by low-flow conditions. Fecal coliform bacteria and nutrient problems are likely the result of municipal and industrial discharges into this and upstream segments.

TABLE 3-7
WICHITA RIVER WASTEWATER DISCHARGES AND WATER IMPOUNDMENTS

County	No. of Wastewater Permits	Maximum Permitted Wastewater Flow (mgd)	Major Impoundments
Cottle	1	0.24	
Foard	6	0.20	Chloride Control Structure Copper Breaks
Knox	0	0.00	Truscott
Wilbarger	8	3.05	Santa Rosa
Baylor	1	0.00	Kemp, Diversion
Wichita	8	28.66	
Clay	10	1.22	
Total	34	-	6

4. Water Quantity. The drainage area for the Wichita River above Lake Kemp Dam at river mile 126.7 is 2,086 square miles while the drainage area between Lake Kemp and Wichita Falls at the mouth of Holliday Creek is 1,240 square miles. Average annual rainfall ranges from 21 inches in the western part of the Wichita River Basin to 28 inches in the eastern part of the basin (Spatial Climate Analysis Service 2000). Stream flows have been analyzed for Reaches 8 (Wichita River downstream of Diversion), 9 (Wichita River main stem), Reach 10 (North and Middle Fork) and Reach 11 (South Fork) as presented in Table 3-8.

TABLE 3-8
WICHITA RIVER STREAM FLOW

Reach	USGS Gage	Average Flow* (cfs)
8	Wichita Falls	82.0
9	Seymour (Modified)**	42.6
10	Truscott	20.0
11	Benjamin	7.6

Source: USACE 2001a
*50% exceedence level
** Multiplied by 1.42 to simulate flows into Lake Kemp

In addition to average flow rates, low flow conditions in the North, Middle and South Forks of the Wichita River were of particular interest to this study. Low flow conditions, for the purpose of this study, have been evaluated for flows less than 1 cfs (limited flow) or less than 0 cfs (no flow but not dry). These scenarios intermittently exist in the Upper Wichita River under natural conditions as described in the following sections.

The USACE performed a study to assess base flow conditions in Reaches 9, 10, and 11 of the Upper Wichita River. While natural conditions are synonymous with observed base flows in Reaches 9 and 10, natural conditions in Reach 11 were calculated based on observed flow plus the average pump rate from Area VIII since the time of construction. Therefore, the base flow for Reach 11 estimates stream flow prior to construction of Area VIII. Base flow rates were taken from data collected by USGS stream gages from October 1961 - September 1998 for Reaches 10 (Truscott Gage) and 11 (Benjamin Gage) while data from December 1959 - September 1979 were used for Reach 9 (Lake Kemp). These results are reported in Table 3-9.

TABLE 3-9
PERCENT OF LOW FLOW AT BASE CONDITIONS BY REACH*

	Reach 10		Reach 11	Reach 9
	cfs≤1	cfs≤0	cfs≤0	cfs≤0
Natural Conditions	1.5	0.0	8.9	1.4
50% Brush Control (27.6% Return)	NA	0.0	7.9	1.4
50% Brush Control (38.9% Return)	NA	0.0	7.8	1.4

Source: USACE 2001a
NA – Not Applicable
* Percentiles rounded to nearest tenth.

Due to growing concern in the Wichita River Basin about the availability of water and its effect on economic growth and development, the Red River Authority of Texas in cooperation with the Texas State Soil and Water Conservation Board (TSSWCB) initiated a study to determine the feasibility of implementing a brush control and management program to increase water yield. The goal is to restore large areas of brush to native grasses, but leave brush buffers and habitat corridors. The results of the study revealed the implementation of the proposed brush control program may be expected to provide a net increase in overall watershed yield (measured at Lake Kemp) ranging from 27.6 % to 38.9 % based on the report's 119,100 acre-feet per year estimated average inflow for the lake (other studies cited in this document report higher inflows for Lake Kemp). The brush control program has currently been included in Texas Senate Bill 1 and the Region B (Red River Authority) Water Plan. Implementation is expected to occur regardless of the outcome of chloride control efforts. The Reevaluation assumed a brush management implementation factor of 50% as its future condition projection – with and without the proposed project. Low flow base conditions with and without brush management are also shown in Table 3-9.

5. <u>Aquatic Invertebrates.</u> Information regarding aquatic instream invertebrate communities within the Wichita River Basin is quite limited. West Texas State University (WTSU) observed invertebrate communities at specific RRCCP areas which included a limited amount of work on the Wichita River. Their observations are summarized below.

The Wichita River system has a relatively limited aquatic invertebrate population, possibly due to the high salt content of the water (WTSU 1972). Most of the invertebrate fauna consisted of crustaceans and insects. Crayfish and amphipods were found in the North and Middle Fork of the Wichita River and calanoid copepods in the Middle Fork of the Wichita River. The most common invertebrates in tributaries of the Wichita River were aquatic insects, including water scavenger beetles, damselflies, dragonflies, water striders, and midges. Horseflies and deerflies were common along the streams and probably breed along the stream shorelines.

6. Fish Resources in Wichita River Basin. Fish communities in the Wichita River Basin have been described by Lewis and Dalquest (1955, 1956, 1957), Dalquest (1958), Dalquest and Peters (1966), Echelle *et al.* (1972), Matthews (1991), Echelle *et al.* (1995), Gelwick, et al (2000), and Clyde (1996). Fish communities in the basin are often subjected to a high degree of variability in flow, temperature, turbidity, and salinity. Consequently, species composition and relative abundance can be highly variable among locations and seasons (Matthews 1991; Taylor *et al.* 1996) and may fluctuate widely over long periods of time (Wilde *et al.* 1996). Because of this, specific fish sampling events have been heavily influenced by the environmental conditions in the river that preceded the sampling events. Therefore, the results of fish collections must be interpreted with some level of caution regarding relative abundance (% of total catch) of various fish species.

Fishery resources in the upper Red River basin including the Wichita River system were described in detail by Wilde *et al.* (1996). Information contained in the 1976 FES was used to identify fish species that have been collected in four reaches of the Wichita River including two reaches on the Wichita River (Reaches 7 and 9), and single reaches on the North Fork of the Wichita River (Reach 10) and South Fork of the Wichita River (Reach 11). Each of these reaches is shown on Figure 3-2, and fish species that have been collected in the four reaches are shown in Table 3-10.

Overall within the Wichita River reaches, a total of 43 fish species were collected. Of these 16 species were collected in all four reaches. Fish species that were collected in all four reaches included:

➢ Gizzard shad	➢ carp	➢ plains minnow	➢ speckled chub
➢ Red River shiner	➢ red shiner	➢ sharpnose shiner	➢ fathead minnow
➢ Bullhead minnow	➢ Red River pupfish	➢ plains killifish	➢ mosquitofish
➢ green sunfish	➢ orangespotted sunfish	➢ bluegill	➢ longear sunfish

Although collected within one or more of the identified reaches within the Wichita River system, almost 50% (21 of 43) of the fish species collected had a low abundance (i.e., less than 1% of the fish collected in all stream reaches). Species with low abundance in the Wichita River system include:

➢ Paddlefish	➢ shortnose gar	➢ goldeye	➢ carp
➢ Silver chub	➢ chub shiner	➢ sand shiner	➢ blacktail shiner
➢ Suckermouth minnow	➢ black buffalo	➢ black bullhead	➢ yellow bullhead
➢ Inland silverside	➢ striped bass	➢ warmouth	➢ orangespotted sunfish
➢ Redear sunfish	➢ spotted bass	➢ largemouth bass	➢ bigscale logperch
➢ Freshwater drum			

TABLE 3-10
COMMON AND SCIENTIFIC NAMES OF FISH SPECIES COLLECTED FROM FISH REACHES IN THE WICHITA RIVER

Common Name	Scientific Name	Reach 7	Reach 9	Reach 10	Reach 11
Paddlefish	*Polyodon spathula*		X		
Longnose gar	*Lepisosteus osseus*	X			
Shortnose gar	*Lepisosteus platostomus*	X			
Gizzard shad	*Dorosoma cepedianum*	X	X	X	X
Goldeye	*Hiodon alosoides*	X			
Red shiner	*Cyprinella lutrensis*	X	X	X	X
Blacktail shiner	*Cyprinella venusta*	X			
Common carp	*Cyprinis carpio*	X	X	X	X
Plains minnow	*Hybognathus placitus*	X	X	X	X
Speckled chub	*Macrhybopsis aestivalis*	X	X	X	X
Silver chub	*Macrhybopsis storeiana*	X			
Emerald shiner	*Notropis atherinoides*	X	X	X	
Red River shiner	*Notropis bairdi*	X	X	X	
Ghost shiner	*Notropis buchanani*	X	X	X	
Sharpnose shiner	*Notropis oxyrhynchus*	X	X	X	X
Chub shiner	*Notropis potteri*	X	X	X	
Sand shiner	*Notropis stramineus*	X	X	X	
Suckermouth minnow	*Phenaeobius mirabilis*	X	X	X	
Fathead minnow	*Pimephales promelas*	X	X	X	X
Bullhead minnow	*Pimephales vigilax*	X	X	X	X
River carpsucker	*Carpiodes carpio*	X	X		X
Smallmouth buffalo	*Ictiobus bubulas*	X	X		
Black buffalo	*Ictiobus niger*	X			
Black bullhead	*Ameiurus melas*	X		X	X
Yellow bullhead	*Ameiurus natalis*			X	
Channel catfish	*Ictalurus punctatus*	X	X		
Red River pupfish	*Cyprinodon rubofluviatilis*	X	X	X	X
Plains killifish	*Fundulus zebrinus*	X	X	X	X
Mosquitofish	*Gambusia affinis*	X	X	X	X
Inland silverside	*Menidia beryllina*	X			
Striped bass	*Morone saxatilis*	X			
White bass	*Morone chrysops*	X	X		
Green sunfish	*Lepomis cyanellus*	X	X	X	X
Warmouth	*Lepomis gulosus*	X	X		
Orangespotted sunfish	*Lepomis humilis*	X	X	X	X
Bluegill	*Lepomis macrochirus*	X	X	X	X
Lonear sunfish	*Lepomis megalotis*	X	X	X	X
Redear sunfish	*Lepomis microlophus*	X			
Spotted bass	*Micropterus punctulatus*	X			
Largemouth bass	*Micropterus salmoides*	X	X	X	
White crappie	*Pomaxis annularis*	X	X		
Bigscale logperch	*Percina macrolepida*	X			
Freshwater drum	*Aplodinotus grunniens*	X	X		

Source: Wilde *et al.* (1996)

Wilde *et al.* (1996) indicated that the sharpnose shiner and paddlefish might be extirpated from the basin as neither species has been collected in the basin since the 1960's.

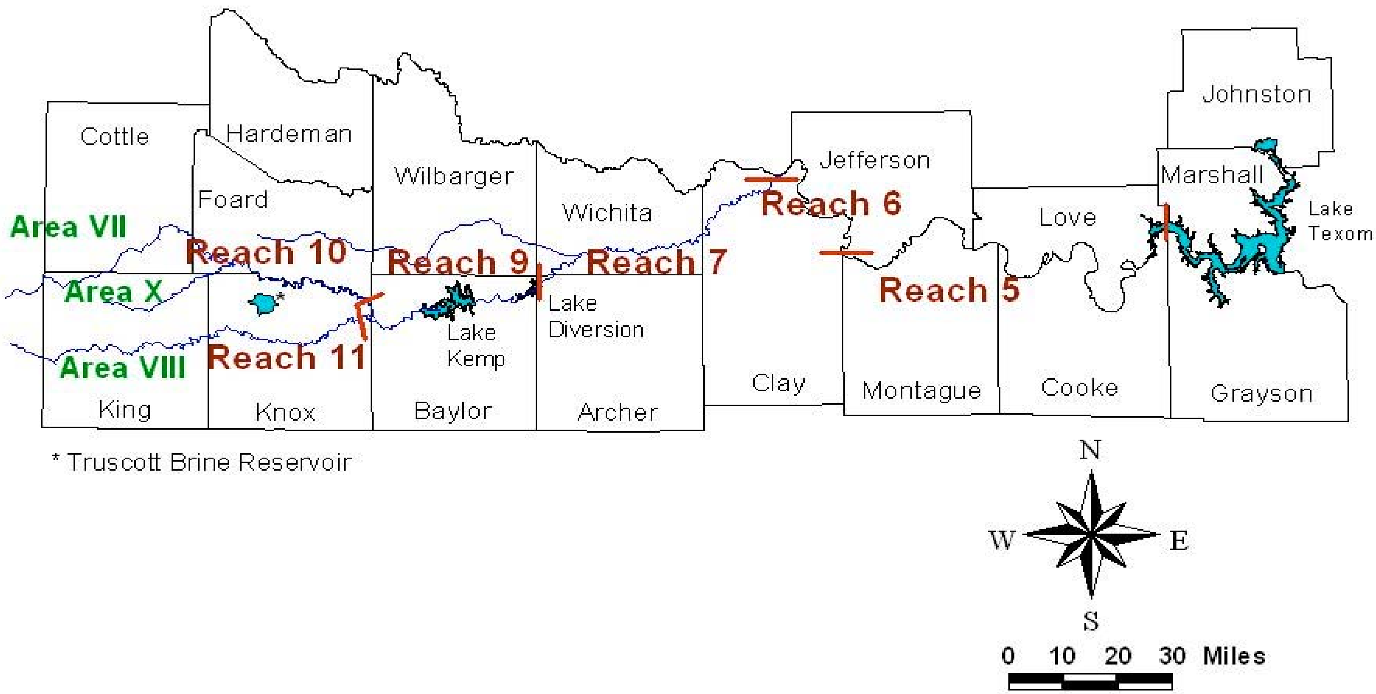
Generally, as one proceeds up the Wichita River system, fishery resources are subjected to harsher environmental conditions associated with lower flows including more frequent no flow periods, higher water temperatures during the summer, and increased levels of salinity. These harsher conditions in the upstream reaches of the river are reflected in the assemblage of fish species that have been collected in each of the stream reaches. On the main stem of the Wichita River, the lower reach (Reach 7) had 41 species and the upper reach (Reach 9) had 30 species. In comparison, sampling on the North Fork of the Wichita River (Reach 10) and the South Fork (Reach 11) recorded 23 and 19 fish species, respectively. In addition to more favorable living conditions, the fish population in Reach 7 is influenced by fish, especially game fish, such as striped bass, white bass, and spotted bass, that have migrated from Lake Texoma up the Red River to the lower reach of the Wichita River. Similarly, fish species sampled in Reach 9 are influenced by fish movement (upstream and downstream) from Lakes Kemp and Diversion.

The USACE provided information by stream reach for the most abundant fish species regarding each species' relative abundance in pre- and post-1970 collections. After reviewing this information for the Wichita River system, the following general observations can be made:

- The relative abundance of plains minnows has decreased throughout the basin,
- The relative abundance of red shiners has increased in the reaches of the Wichita and North Fork of the Wichita Rivers, and
- The relative abundance of Red River pupfish has increased in the North Fork and South Fork of the Wichita River.

Species composition appears to be frequently associated with habitat type and salinity. In regard to habitat, main stem habitat that is wide and shallow and has sandy substrate where turbidity and salinity are frequently high is primarily occupied by the plains minnow, Red River shiner, chub shiner, and speckled chub. In main stem and tributary streams, red shiners, sunfish species, fathead minnow, bullhead minnow, and mosquitofish frequently occupy habitat containing deeper water (flowing or pool areas), with silt bottom, and woody debris. Plains minnow, Red River shiner, mosquitofish, green sunfish, chub shiner, and speckled chub are tolerant of high salinity and are often found in areas with salinity as great as 20,000 mg/l to the exclusion of other species. In areas where salinity may exceed 20,000 mg/l (includes areas in Reaches 10 and 11), only Red River pupfish and plains killifish are found in abundance as both species have extremely high salt tolerance and may survive salinity concentrations as high as 100,000 mg/l (Wilde et al 1996). The fish species assemblage shown in Table 3-10 for the North Fork of the Wichita River and South Fork of the Wichita River does not reflect the harsh environment that occurs immediately downstream of the major sources of salinity.

FIGURE 3-2
FISH ANALYSIS REACHES



c. Upper Red River Basin from Confluence with Wichita River to Lake Texoma

1. Description. The study area for the Upper Red River includes the basin from its confluence with the Wichita River at river mile 907 downstream to Lake Texoma. Overall, the Red River is an interstate stream, which originates in Curry County, New Mexico, as Tierra Blanca Creek and flows along the Texas/Oklahoma border into southwestern Arkansas and then turns south into Louisiana, where it discharges into the Mississippi near Simmesport, Louisiana. The main stem of the Red River has a total length of 1,217 river miles. The topography of the basin ranges from flat prairie in the western reach at an elevation of approximately 4,835 feet NGVD to rolling hills in eastern Texas at an elevation of approximately 495 feet NGVD.

2. Water Quality. Water quality in the upper Red River is influenced by both natural and anthropogenic discharges. Chloride, sulfate, and TDS data for hydrologic Reaches 6 and 7 are shown in Table 3-11.

TABLE 3-11
WATER QUALITY IN UPPER RED RIVER HYDROLOGIC REACHES

Reach	Chloride (mg/l)	Sulfate (mg/l)	TDS (mg/l)
6	1,183	632	3,053
7	990	495	2,504

Source: USACE 2001a
*50% exceedence level

(a) Anthropogenic Influences. Human populations living in north-central Texas and south-central Oklahoma extensively use rivers in the study area. Uses include municipal and industrial water supply, recreation, flood control, wastewater disposal, agricultural activities, and petroleum exploration and production. Table 3-12 lists some uses, including maximum permitted water discharges and major impoundments for the states of Texas and Oklahoma in the study area. Wastewater discharges listed on Table 3-6 include discharges from industries, municipalities, and individual proprietors. Reaches of the river with no permitted wastewater discharges reflect the lack of human population. Though not required to have wastewater discharge permits, other activities such as agriculture and oil and gas exploration and production potentially impact water quality in the basin.

Additional Red River water quality data from upstream of its confluence with the Wichita River was provided by the TNRCC. According to the TNRCC data screening, concerns exist for nutrients and dissolved metals and a possible concern for fecal coliform bacteria. A possible source of the nutrients is municipal discharges. As a result, elevated levels of fecal coliform bacteria do not support contact recreation use.

TABLE 3-12
UPPER RED RIVER WASTEWATER DISCHARGES AND WATER IMPOUNDMENTS
STATES OF OKLAHOMA AND TEXAS

County	No. of Wastewater Permits	Maximum Permitted Wastewater Flow (mgd)	Major Impoundments
TEXAS			
Clay	10	1.22	Arrowhead
Montague	3	0.13	
Grayson	23	20.86	
OKLAHOMA			
Cotton	2	NA	
Jefferson	1	NA	Waurika

NA - Not available

(b) Selenium. Elevated concentrations of Se occur naturally in surface waters of the general area. While natural background concentrations of Se in freshwater environments are typically less than 0.2 µg/l (Skorupa *et al.* 1996), concentrations appear to be much higher in the upper Red River Basin. For example, data from USGS gaging stations on the Salt Fork of the Red River near Elmer, Oklahoma, and near Wellington, Texas, indicate that total Se concentrations range from approximately 1 to 9 and 3 to 29 µg/l, respectively, at these locations, which are upstream of the Red River study area. The upper end of this naturally-occurring range exceeds concentrations of Se reported as hazardous to health and long-term survival of fish and wildlife populations (Lemly 1993, 1995).

3. Water Quantity. The upper Red River Basin watershed receives an average annual precipitation varying from 34 inches near its confluence with the Wichita River to 38 inches at Lake Texoma. Stream flow in Hydrologic Reach 7, in the upper Red River study area has a flow rate of 653 cfs, 50% of the time. Similarly, the downstream Hydrologic Reach 6 has a flow rate of 971 cfs, 50% of the time (USACE, 2001b).

4. Aquatic Invertebrates. Information about aquatic invertebrates in the Red River upstream from Lake Texoma is scarce as long reaches of the river cross private lands and few roads exist. These reaches are basically inaccessible without permission from landowners. Stream margins throughout the basin provide breeding habitat for horseflies and deerflies, which become abundant at certain times of the year.

Other than the survey conducted in the early 1970’s by WTSU under contract to the USACE for baseline information on streams that could be affected by the RRCCP, no other written information could be found about the structure of aquatic invertebrate communities upstream from Lake Texoma. The USACE reported that verbal communications with faculty members at the University of Oklahoma at Norman, Texas Tech University at Lubbock, and the University of North Texas at Denton produced no additional information. Neither the Oklahoma Biological Survey at Norman nor the TPWD had any aquatic invertebrate information for the project area.

5. Fish Resources in the Upper Red River Basin: The only portion of the upper Red River that could be affected by the proposed project is that portion between the confluence of the Wichita River and Lake Texoma and includes that portion of the Red River shown as Reaches 5

and 6 on Figure 3-2. Therefore, the discussion of fish resources within the Red River has been limited to these two reaches of the river. Although not to the extent that occurs in the Wichita River, fish in these reaches of the Red River are also subject to considerable variations in flow, temperature and salinity levels. As discussed for the Wichita River, environmental conditions in the river prior to a fish sampling event can have a large influence on the sampling results. Therefore, again, some level of caution should be exercised when evaluating changes in relative abundance (% of total catch) of different fish species.

The Wilde *et al.* (1996) identified fish species that have been collected in Reaches 5 and 6 of the Red River from Lake Texoma upstream to the confluence of the Wichita River. A list of fish species that have been collected in these reaches of the Red River is provided in Table 3-13. Of the species collected, the abundance of 49 of the species (80% of the species) had an individual abundance of less than 1%. Three species (red shiner, plains minnow, and emerald shiner) had relative abundance greater than 5% in both reaches of the Red River (Wilde *et al.* 1996). These three species comprised over 85 and 65% of the fish that have been collected from Reaches 5 and 6, respectively. With the exception of the sharpnose shiner, all 16 fish species that were collected in all reaches of the Wichita River were also collected in both reaches of the Red River. The larger assemblage of fish species in the Red River when compared to the Wichita River is likely attributable to being located immediately upstream from Lake Texoma and more desirable environmental conditions within the river. Three fish species collected in Reaches 5 and 6 (Red River pupfish, Red River shiner, and speckled chub) have been identified by resource agencies as being of special concern because of their limited distribution.

TABLE 3-13
COMMON AND SCIENTIFIC NAMES OF FISH SPECIES
COLLECTED FROM FISH REACHES OF THE UPPER RED RIVER

Common Name	Scientific Name	Reach 5	Reach 6
Shovelnose sturgeon	*Scaphirhynchus platorynchus*		X
Longnose gar	*Lepisosteus osseus*	X	X
Shortnose gar	*Lepisosteus platostomus*	X	X
Gizzard shad	*Dorosoma cepedianum*	X	X
Threadfin shad	*Dorosoma petenense*	X	X
Goldeye	*Hiodin alosoides*	X	X
Stoneroller	*Campostoma anomalum*	X	
Red shiner	*Cyprinella lutrensis*	X	X
Blacktail shiner	*Cyprinella venusta*	X	X
Common carp	*Cyprinis carpio*	X	X
Silvery minnow	*Hybognathus nuchalis*	X	X
Plains minnow	*Hybognathus placitus*	X	X
Speckled chub	*Macrhybopsis aestivalis*	X	X
Silver chub	*Macrhybopsis storeiana*	X	X
Golden shiner	*Notemigonus crysoleucas*	X	X
Emerald shiner	*Notropis atherinoides*	X	X
Red River shiner	*Notropis bairdi*	X	X
Ghost shiner	*Notropis buchanani*	X	X

Table 3-13 continued

Common Name	Scientific Name	Reach 5	Reach 6
Chub shiner	*Notropis potteri*	X	X
Sand shiner	*Notropis stramineus*	X	X
Suckermouth minnow	*Phenaeobius mirabilis*	X	X
Fathead minnow	*Pimephales promelas*	X	X
Bullhead minnow	*Pimephales vigilax*	X	X
River carpsucker	*Carpiodes carpio*	X	X
Smallmouth buffalo	*Ictiobus bubulas*	X	X
Bigmouth buffalo	*Ictiobus cyprinellus*	X	X
Black buffalo	*Ictiobus niger*	X	
Golden redhorse	*Moxostoma eythrurum*	X	X
Black bullhead	*Ameiurus melas*	X	X
Yellow bullhead	*Ameiurus natalis*	X	X
Blue catfish	*Ictalurus furcatus*	X	X
Channel catfish	*Ictalurus punctatus*	X	X
Tadpole madtom	*Noturus gyrinus*		X
Freckled madtom	*Noturus nocturus*		X
Flathead catfish	*Pylodictis olivaris*	X	X
Red River pupfish	*Cyprinodon rubofluviatilis*	X	X
Blackstripe topminnow	*Fundulus notalas*	X	
Plains killifish	*Fundulus zebrinus*	X	X
Mosquitofish	*Gambusia affinis*	X	X
Brook silverside	*Labidesthes sicculus*	X	
Inland silverside	*Menidia beryllina*	X	X
Striped bass	*Morone saxatilis*	X	X
White bass	*Morone chrysops*	X	X
Green sunfish	*Lepomis cyanellus*	X	X
Warmouth	*Lepomis gulosus*	X	X
Orangespotted sunfish	*Lepomis humilis*	X	X
Bluegill	*Lepomis macrochirus*	X	X
Lonear sunfish	*Lepomis megalotis*	X	X
Redear sunfish	*Lepomis microlophus*	X	X
Spotted bass	*Micropterus punctulatus*	X	
Largemouth bass	Micropterus salmoides	X	X
White crappie	*Pomaxis annularis*	X	X
Black crappie	*Pomaxis nigromaculatus*	X	X
Mud darter	*Etheostoma asprigene*	X	
Orangebelly darter	*Etheostoma radiosum*	X	
Orange throated darter	*Etheostoma spectabile*	X	
Logperch	*Percina caprodes*	X	X
Bigscale logperch	*Percina macrolepida*	X	X
Sauger	*Stizostedion canadense*		X
Walleye	*Stizostedion vitreum*	X	
Freshwater drum	*Aplodinotus grunniens*	X	X

Source: Modified Wilde et at. 1996

Of the species that have been reported to have been collected from these reaches of the Red River, Wilde *et al.* (1996) identified three species (sharpnose shiner, freckled madtom, and shovelnose sturgeon) that are possibly extirpated from the basin. All three of these species have not been collected from the basin since the 1960's (Wilde *et al.* 1996).

The upper Red River supports a commercial bait minnow fishery that appears to be highly variable. The USFWS (1994) reported 49,000 pounds (lbs) of minnows commercially harvested from the upper Red River in 1991. The ODWC (Wallace and Driscoll 1994) reported the commercial minnow harvest from the upper Red River in Oklahoma to be considerably less for 1993, with a total of 27,350 lbs. Commercial bait minnows consisting primarily of "River shiners" were reportedly harvested from the North Fork of the Red River (18,500 lbs), the Red River (7,850 lbs), and the Salt Fork of the Red River (1,000 lbs). No data are available regarding the impacts of commercial minnow harvest on fish communities, but it could be a factor in the general decline of some minnow species throughout the upper basin .

d. Truscott Brine Disposal Reservoir. Truscott Brine Disposal Reservoir was designed as a brine disposal site, receiving collected brines from the collection sites. The economic life of the lake is 100 years for evaluating costs and benefits. The functional life of the reservoir is indefinite. The lake is located on Bluff Creek, a south bank tributary of the North Fork of the Wichita River, at river mile 3.6. The drainage area of the basin is 26.2 miles and begins approximately 2 miles west and 2.5 miles south of Truscott, Texas. The drainage area extends approximately 6 miles northeastward to the dam site and ranges in width from 7 miles at the upper end of the basin to approximately 3 miles at the dam site. The project has been collecting brine since 1987.

1. Water Quality. The water quality of Truscott Brine Disposal Reservoir is influenced by the brine collection areas, evaporation, and contributions from stormwater (freshwater runoff in the Bluff Creek watershed). Water quality data have been collected as part of the Wichita River Basin monitoring program. Baseline Se data for Truscott Brine Disposal Reservoir was collected in 1992. Data collected during reservoir filling indicated overall selenium concentrations of 2 μg/l. Additional monitoring was conducted in 1997 and 1998 (USACE 2001c). This monitoring for Truscott Brine Disposal Reservoir included four sampling sites ranging from Truscott Dam to the extreme upper end of the impoundment and occurred over a range of seasons. Water samples were collected in both surface and near-bottom waters and analyzed for total Se concentration. Total Se concentrations for the 1997-1998 monitoring were below analytical detection limits (ranging from 0.5 to 1.0 ug/l). The last samples, collected in September 1998, indicated that waterborne total selenium concentrations were still less than the 0.5 ug/l detection limit after approximately 11 years of project operation collecting brine from Area VIII only.

Mass balance analysis of the reservoir Se concentrations shows that a significant portion of the incoming Se has been lost to volatilization and sediment adsorption (USACE 2000a). Volatilization of methylated Se compounds has been demonstrated to be a significant source of Se mass loss in a number of systems (USACE 1993a). Cooke and Bruland (1987) reported that outgassing of Se may have been substantial in Kesterson Reservoir and estimated that roughly 30% of Se introduced to the system was volatilized to the atmosphere. Similarly, Thompson-Eagle and Frankenberger (1990) reported a 35% loss of the total Se inventory of pond water from Kesterson reservoir after 43 days of incubation. Changes in water column and sediment partition coefficients are also known to be a process of major importance in lakes (Bowie *et al.* 1996). Incorporation of these factors into Se modeling for the reservoir has been shown to accurately reflect Se losses from the time of impoundment to the sample collection dates (USACE 2000a).

2. Fish and Wildlife Resources of Truscott Brine Disposal Reservoir. Only a limited amount of information is available regarding fish resources in Truscott Brine Disposal Reservoir. Echelle *et al.* (1995) reported on a sample of fish collected from the reservoir at a time when the salinity in the reservoir was 18,000 mg/l. As would be expected with this level of salinity, fish present in the sample were limited to three salt tolerant species including Red River pupfish (49%), plains killifish (43%), and mosquitofish (8%). This data would indicate that Truscott

Brine Disposal Reservoir is presently providing additional habitat for salt tolerant fish species. However, the desirability of this habitat even for the salt tolerant fish species is dependent on salt concentrations in the reservoir. Salinity in the reservoir would change if the reservoir receives additional brines from operation of project components.

A total of three freshwater ponds are located on the north side of Truscott Brine Disposal Reservoir and provide a total of approximately 200 surface-acres of freshwater. An additional pond has been constructed but has not filled with water due to recent drought conditions in northern Texas. The freshwater ponds have been stocked with largemouth bass, channel catfish, blue catfish, and crappie.

4. Recreation. Truscott Brine Disposal Reservoir is located within Texas Planning Region 7 (West Central). Region 7 is composed of 19 counties totaling 16,936 square miles. The population in 2000 was 320,648. According to the 1990 Texas Outdoor Recreation Plan (TORP), Region 7 has a total of 21,000 acres of recreation land, including 7,565 acres of developed recreation land and 57,041 surface acres of lakes. The region has 58 acres of recreation land per thousand people, well below the statewide average. According to the 1990 TORP, facilities needed include off-road vehicle riding areas, softball fields, tennis courts, fishing structures, and boat ramp lanes.

Freshwater ponds associated with Truscott Brine Disposal Reservoir provide additional recreational resources for Region 7. The fishing resource attracts local sportsmen.

According to the USACE Research and Development Center, Truscott receives approximately 7,500 visitors annually that primarily boat and hunt at the facility. The 2,300 surface-acre Truscott Brine Disposal Reservoir is not stocked with fish and, therefore, does not provide fishing at the present time. The area provides hunting of wild hogs, ducks, quail, turkey, dove and the 30-40,000 geese that winter on the reservoir and ponds. Other recreational opportunities include a 7-mile nature trail that surrounds the freshwater ponds, four primitive camp sites, a restroom, and a group picnic shelter located near the reservoir.

e. Lake Kemp and Lake Diversion.

1. Description. Lake Kemp, located 6 miles north of Seymour, Texas, is formed by the Wichita River, which is dammed in north-central Baylor County at river mile 126.7. The lake is used for irrigation and serves as a backup water supply for Wichita Falls. Its elevation is 1,144 feet above sea level and the dam elevation is 1,183 feet. The total drainage area for the lake is 2,100 square miles, and the lake covers an area of 16,540 acres. Maximum lake depth from streambed to conservation elevation pool is 76 feet. The local, deep, loamy soil supports grasses and wild upland plants. There are more than 100 miles of shoreline that furnish a variety of recreation opportunities.

2. Water Quality. Data from Hydrologic Reach 9, which includes Lakes Kemp and Diversion, indicate chloride concentrations of 1,312 mg/l, sulfates of 755 mg/l, and TDS of 3,254 mg/l, 50% of the time (USACE 2001a). Data from the TNRCC for Lake Diversion (at the outlet of Lake Kemp) indicates that even the minimum TDS values are greater than the EPA secondary drinking water standards (250 mg/l). Chlorides originating from natural sources are significant enough to prohibit use of the lake for domestic water supply without advanced treatment.

Wilde (1999) sampled Lake Kemp in 1997. In general, sampling was conducted in accordance with the monitoring plan developed by Burks (1996). Lake Kemp was sampled during April through December 1997. Sampling sites were chosen to include two locations representative of limnetic conditions, two locations that were transitional between riverine and limnetic conditions, and two locations that were riverine in nature, for a total of six sampling sites, as opposed to the five sites originally recommended by Burks (1996). Based on a comparison of his results with those of previous studies, Wilde suggested that chloride loading into the lake may have decreased by as much as 33% between 1992 and 1997.

Wilde sampled Lake Kemp again in 1999 - 2000. Again, sampling was conducted in accordance with the monitoring plan developed by Burks (1996), with the exception of the number of sites sampled. Sampling was conducted from June 1999 through February 2000 at approximately the same six locations on Lake Kemp as Wilde's previous study in 1997. Compared with the 1997 results of Wilde (1999), concentrations of TDS, calcium, potassium, sodium, chloride, and sulfate increased in Lake Kemp in 1999 – 2000 as shown in Table 3-14. Except for potassium, which was present in low concentrations, the increase in concentrations from 1997 to 1999 - 2000 ranged from 6 to 19%. The increase between studies is probably due, at least in part, to low runoff into Lake Kemp in 1999 - 2000 (Wilde 2000). As a result of reduced inflows into Lake Kemp during 1999 - 2000, the overflow, observed in 1997 and indicated by low conductivity waters, did not develop in 1999.

TABLE 3-14
LAKE KEMP WATER QUALITY, 1997 TO 1999-2000

Parameter	1997 Concentrations (mg/l)	1999-2000 Concentrations (mg/l)	Percent Change (rounded)
TDS	2,781	3,131	13
Calcium	250	297	16
Potassium	8.1	12.0	32
Sodium	635	675	6
Chloride	1,021	1,170	13
Sulfate	791	867	9

Source: Wilde 1999, 2000

Wilde (1999) suggested that several lines of evidence indicated that chloride concentrations in Lake Kemp had decreased since the mid-1980s, but that the available evidence was not conclusive because variation in sampling and analytical protocols and seasonal and inflow (dilution) related variation in chloride concentrations might account for some of the observed temporal differences in chloride concentrations. Results of the present study, showing a lake-wide increase in chloride concentrations between 1997 and 1999-2000, further complicate any attempt to determine whether chloride concentrations in Lake Kemp have decreased since operation of the Bateman chloride control facility began in 1986. Monitoring of the lake would continue assessing the actual impact of chloride control.

3. <u>Water Quantity and Use.</u> Lake Kemp currently is utilized for the following purposes:

- Irrigation – 80,000 acre-feet per year
- Municipal – 0 acre-feet per year
- Industrial – 10,000 acre-feet per year
- Recreation – 5,850 acre-feet per year
- Dundee Fish Hatchery – 2,200 acre-feet per year

Drought contingency plans are based on water usage from the lake. These plans were developed as a result of State Senate Bill 1. The drought contingency plan created action levels that required reductions in water usage at specific elevations. The action levels included in the drought contingency plan are shown in Figure 3-3.

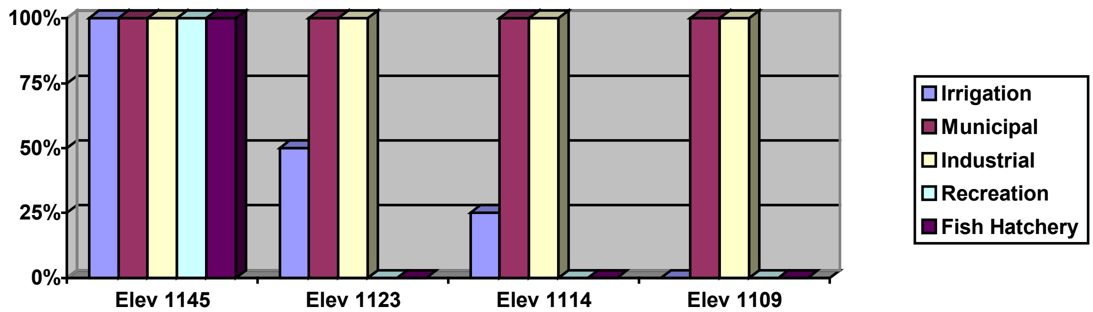


FIGURE 3-3
DROUGHT CONTINGENCY PLAN CONDITIONS

Data from the USACE 2000 Annual Report (USACE 2000b) show the long term average inflow for Lake Kemp to be 188,600 acre-feet per year for the period of record from 1924-2000. A review of inflows for Lake Kemp for 1988-2000, the period of record after construction of Area VIII, shows an average annual inflow of 186,952 acre-feet per year. This may indicate that the removal of brine flows from the upper reaches of the basin has had minor effects on inflow into Lake Kemp or may reflect different weather conditions. The difference is less than 1%.

Concern over decreases in Lake Kemp elevations have been voiced by the TPWD, which operates the Dundee Fish Hatchery below Lake Diversion. Lake Diversion is a downstream extension of Lake Kemp. Under the current Drought Contingency Plan, the hatchery below Lake Diversion will not receive water when the Lake Kemp elevation is below elevation 1,123. Under existing conditions and existing conditions with brush control, the lake is above elevation 1,123 almost 100% of the time.

4. Fish Resources of Lake Kemp and Lake Diversion. Lake Kemp was surveyed in 1990-1991, 1992, and 1998 (TPWD 1993, 1999) using gill nets, trap nets, and electroshocking. Fish species collected during each of the surveys is shown in Table 3-15.

TABLE 3-15
FISH SPECIES COLLECTED IN LAKE KEMP DURING
FISH SURVEYS IN 1990-1991, 1992, AND 1998

Species	1990-1991	1992	1998
Spotted gar	X		X
Gizzard shad	X	X	X
Common carp	X	X	X
River carpsucker	X	X	X
Smallmouth buffalo	X	X	X
Blue catfish		X	X
Channel catfish	X	X	X
Flathead catfish	X	X	
White bass	X	X	X
Striped bass	X	X	X
Redbreast sunfish		X	X
Green sunfish	X	X	X
Warmouth	X	X	
Bluegill	X	X	X
Longear sunfish	X	X	X
Spotted bass	X	X	X
Largemouth bass	X	X	X
White crappie	X	X	X
Logperch		X	
Freshwater drum	X	X	X
Total Number of Species	17	19	17

Source: TPWD 1993, 1999

As would be expected with a large main stem reservoir, the overall fish population was composed of sportfish species (e.g., catfish, bass, crappie, etc.), forage species (e.g., shad, bluegill, etc.), and non-game fish species (e.g., gar, carp, suckers, etc.). Species composition was quite similar between the three years with a total of 20 species being collected the first year and 17 species the second year and 19 species the third year. Sixteen of the 20 species were collected in all three years. The TPWD (1999) reported on the results of the 1998 survey and provided the following general information:

- Forage fish were abundant and consisted primarily of gizzard shad and bluegill that could be highly utilized by most sport fish. Due to their small size, bluegills are a valuable forage species, but they provide an insignificant sport fishery.
- Catch rates for blue and channel catfish were both low in 1998 and could have been attributable to colder water temperatures during the survey period. From a historical perspective, the catfish populations in the lake remain stable and continue to provide recreation for catfish anglers.
- The striped bass population in Lake Kemp remains strong with a large number of individuals just below the legal size (18 inches) for harvest. The high number of individuals just below the minimum size limit suggests that many of the fish are being harvested soon after they reach 18 inches and that an excellent sport fishery will be maintained as these fish grow into harvestable size. Growth rates of striped bass remained slow and this suggests that the forage base in the lake is controlling growth. In

response to this concern, threadfin shad were stocked in Lake Kemp in 1999 (TPWD 1999).

- White bass catch rates have decreased over the last four fish surveys. It is possible that the relatively large striped bass population is adversely affecting the white bass population in Lake Kemp.
- The catch rate of spotted bass in 1998 was much higher than in previous years and was at least partially due to a more powerful electroshocker. The majority of the spotted bass collected was less than 12 inches in size and none were over 14 inches in size. Spotted bass are not highly sought or valued by Lake Kemp anglers (TPWD 1999).
- Although the catch rate of largemouth bass was substantially higher in 1998 than in previous years (at least partially attributable to a more powerful electroshocker), the catch rate was still less than the historical average of lakes in the district. Most of the largemouth bass collected were young-of-the-year fish. Overall, the lake does not provide a high quality sport fishery for largemouth bass.
- The white crappie population remained stable, but is not an exceptionally strong population. Reproduction and recruitment appear to be adequate to maintain the existing sport fishery.

Fish species that have been collected in Lake Diversion in recent years (1997 and 2000-2001) using gill nets, trap nets, and electroshocking are shown in Table 3-16 (TPWD 1998, 2001a). As shown, the species composition in both years was quite similar, with 19 and 22 species being collected in 1997 and 2000-2001, respectively. Similar to Lake Kemp, the fish population is comprised of sportfish species (e.g., catfish, bass, crappie, etc.), forage species (e.g., shad, bluegill, etc.), and non-game species (e.g., gar, carp, suckers, etc.). TPWD (1998) provided the following comments regarding the lake's fishery (primarily sport fishery):

- The catch rate for forage species was below historical average catch rates for the district, but forage species was higher in 1997 than in previous years.
- The abundance of forage fish in the lake appears to be adequate to support the existing sport fishery as all sportfish were in good body condition and growth rates were within acceptable levels (TPWD 1998).
- Lake Diversion continues to provide a good sport fishery for blue and channel catfish. Blue catfish numbers in recent surveys have increased while channel catfish numbers have decreased.
- Striped bass are not directly managed in Lake Diversion, but a population exists in the lake due to downstream movement of individuals from Lake Kemp. Striped bass provide a bonus fish for anglers in Lake Kemp. White bass catch rates in the lake in 1997 were less than the catch rate for striped bass.
- The catch rate of largemouth bass in 1997 was higher than previous years and was attributed to a strong young-of-the-year class in the lake in 1997. Overall, the lake does not provide a high quality largemouth bass fishery.
- The 1997 sample reflected a well-balanced white crappie population including abundant numbers of young-of-the-year and juveniles and adequate numbers of harvestable sized adults. Reproduction and recruitment appeared to be adequate to maintain the existing sport fishery.
- A few (i.e., 10) walleye were collected during the 2000-2001 fish survey, and the presence of these individuals indicates some level of success of the walleye fingerling stocking program that was initiated on Lake Kemp after the 1997 fish survey. Over the 3-year period (1998-2000), the Texas Parks and Game Department stocked in excess of 280,000 walleye fingerlings in Lake Diversion (TPWD 2001a).

TABLE 3-16
FISH SPECIES COLLECTED IN LAKE DIVERSION DURING
FISH SURVEYS IN 1997 AND 2000-2001

Species	1997	2000-2001
Spotted gar	X	X
Longnose gar	X	X
Shortnose gar	X	X
Gizzard shad	X	X
Threadfin shad		X
Common carp	X	
River carpsucker	X	X
Smallmouth buffalo	X	X
Blue catfish	X	X
Channel catfish	X	X
Flathead catfish		X
White bass	X	X
Striped bass	X	X
Green sunfish		X
Warmouth	X	X
Orangespotted sunfish	X	X
Bluegill	X	X
Longear sunfish	X	X
Spotted bass	X	X
Largemouth bass	X	X
White crappie	X	X
Walleye		X
Freshwater drum	X	X
Total Number of Species	19	22

Source: TPWD 1998, 2001a

5. Dundee State Fish Hatchery. Information on the Dundee State Fish Hatchery has been developed from the TPWD (2001b) website. The Dundee State Fish Hatchery was built in 1927. It originally consisted of 44 ponds (32.9 surface acres of water) which included a fish holding house. In 1978, the hatchery was expanded to 91 ponds (78.3 surface acres of water). A new spawning building was added to the facility in 1986 and is used mainly for the spawning of striped bass brood fish. In September 1993, construction was completed on 73 new "state-of-the-art" ponds with polypropylene membrane liners and improved water, electrical, and air supplies. With the new ponds, the Dundee Hatchery has a total of 97 ponds, with 73 lined ponds totaling 59.5 surface acres of water and 24 earthen ponds totaling 23 surface acres of water.

In recent years, the hatchery has been significantly impacted by blooms of a toxic alga which has entered the hatchery system. The golden alga, *Prymnesium parvum*, is a flagellated yellow-green alga of the class Prymnesiophyceae, is a common component of marine phytoplankton, and is typically associated with estuaries. This toxic alga has been associated with numerous fish kills in many parts of the world and was first documented as the cause of fish kills in Texas in 1985. The TPWD have reported approximately 20 fish kills attributed to *P. parvum* since 1985. Estimated fish mortality ranges from 20-30 million individuals since 1985. Currently the range of *P. parvum* has extended into the Pecos, Colorado, Brazos, and Red River systems. Lake Diversion supplies the source water and is the site of the TPWD's Dundee Fish hatchery, which supplies considerable quantities of striped and largemouth bass to stock the states lakes and rivers. In 2001, a *P. parvum* bloom at the hatchery caused the death of the entire year's production of striped bass and most of the brood stock of largemouth bass in the hatchery (TPWD 2001c).

This facility is currently the largest Texas state hatchery in operation. The Dundee State Fish Hatchery produces 25 to 30 million fish annually, including northern largemouth bass, smallmouth bass, channel catfish, white crappie, walleye, sunfish, striped bass, hybrid striped bass, rainbow trout, and yellow perch. Forage fish are also produced for the largemouth bass, and smallmouth bass programs throughout the state. Specific data on hatchery production includes.

- The Dundee Hatchery produces millions of striped bass (*Morone saxatilis*) and hybrid striped bass (*Morone saxatilis x Morone chrysops*) fingerlings annually for stocking into Texas waters. In addition to fingerling production, fry are produced to be utilized in trades with other states. The hatchery produces almost 100% of striped bass for stocking in Texas lakes.

- Koi carp are raised at the Dundee Hatchery for the sole purpose of forage for the state hatchery systems' black bass brood fish. The Dundee Hatchery produces approximately 6 million koi fingerlings yearly for the black bass program statewide.

- The Dundee Hatchery keeps approximately 1,500 adult smallmouth bass brood fish on the hatchery year round. The Dundee Hatchery annually produces between 500,000 and 1 million smallmouth fingerlings.

- The Dundee Hatchery produces approximately 100,000 eight-inch channel catfish for the urban fisheries program each year. Dundee also produces 13,000 one-pound channel catfish annually for the statewide Kidfish program.

- The Dundee Hatchery normally distributes 37,500 rainbow trout during December, January, February, and March.

6. Lake Kemp/Lake Diversion Recreation. Lake Kemp and Lake Diversion are privately owned lakes with limited fee-based public access. These lakes are located in Texas Planning Region 3 (North Texas) which is composed of 11 counties totaling 9,460 square miles. The population was 224,366 in 2000. In 1990, Region 3 was listed as having a total of 40,808 acres of recreation land, 2,839 acres of developed recreation land, and 57,092 surface acres of lakes. The region has 170 acres of recreation land per thousand people, which falls slightly below the statewide average of 209 acres per thousand people. Projected additional outdoor recreation facilities needed in Region 3 include boat ramp lanes, camp sites, hiking trails, horseback riding trails, off-road vehicle areas, playgrounds, team sports facilities, and multi-use trails.

The W.T. Waggoner Estate (Waggoner Ranch) owns the land surrounding Lake Kemp and Lake Diversion and leases property around both lakes for cabins and temporary structures. Visitors use Lake Kemp and Lake Diversion primarily in the spring and summer months for recreational activities, including boating, fishing, swimming, primitive camping, and other water-based activities. Lake Kemp has six public boat ramps with three entrance points, Pony Creek, Moonshine, and Flippen Creek. Only one of these ramps is accessible during drought conditions. Lake Kemp does not have a marina or access to boat fuel or fishing supplies. Lake Diversion has one public boat ramp and a small marina that has fishing supplies but no watercraft fuel.

According to Waggoner Ranch representatives, during the spring and summer months it is estimated that an average of 100 people visit Lake Kemp per day and an average of 10 people visit Lake Diversion per day. During 2000, Lake Kemp had approximately 16,000 visitors. During the cooler fall and winter months, an average of 25 people visit Lake Kemp per weekend day and 3 people visit Lake Diversion per weekend day, while fewer people visit on weekdays. Visitors pay a fee for access to the lake area, which is limited to paying users.

f. Lake Texoma. With its dam located at river mile 725.9 on the Red River between Oklahoma and Texas, Lake Texoma is an 89,000 surface-acre impoundment. Completed in 1944 by the USACE, the lake occupies portions of both south-central Oklahoma and north-central Texas. At normal pool elevation, 617.0 feet, maximum depth is 112 feet and mean depth is approximately 30 feet . Lake Texoma drains an area of approximately 39,719 square miles, with 5,936 square miles non-contributing, most of which is pasture and cropland.

The lake was constructed for flood control, regulation of Red River flows, improvement of navigation and hydroelectric power. Water supply, and recreation were added later as project purposes. Based on a 1985 sediment resurvey, the conservation pool is projected to contain 1,114,909 acre-feet of storage in 2044. The conservation storage pool includes 150,000 acre-feet of water supply storage (150.0 mgd yield). Section 838(a) of the Water Resources Development Act of 1986 (Public Law 99-662) authorizes the Secretary of the Army to reallocate an additional 300,000 acre-feet of hydropower storage to water supply, allowing up to 150,000 acre-feet each for Oklahoma and Texas municipal, industrial, and agricultural water users.

Lake Texoma is a major resource for recreational activities and potable water to residents in the surrounding areas of Texas and Oklahoma. Because of its resource importance, Lake Texoma, more than any of the water bodies in this study, has been thoroughly investigated by many parties over many years. This section summarizes research that has been completed for the lake.

1. Water Quality. General water quality is characterized by moderate to high levels of salinity with a predominance of sodium and calcium salts of chloride and sulfate (Leifeste *et al.* 1971). Chloride and sodium are the most abundant ions in Lake Texoma. From historical data the lake has been classified as mesotrophic based on chlorophyll *a* concentrations (Ground and Groeger 1994). Based on chlorophyll *a* concentrations for the Main Lake Zone (near dam) from Atkinson *et al.* (1999) during the summer months trophic status ranged from mesotrophic to hypereutrophic with a mean trophic classification of slightly eutrophic.

In a report by Atkinson *et al.* (1996), selected water quality data from Lake Texoma were reviewed to provide background information in developing a water quality monitoring program for Lake Texoma. Historical data relating to chloride and sulfate concentrations throughout the lake defined four zones; the Upper Red River Arm (lotic zone), the Red River Transition Zone, the Main Body (lacustrine zone), and the Washita Arm (lotic zone). It was hypothesized that a Washita River Transition zone existed, however, monthly data from Stanford and Zimmerman (1978), Stanford *et al.* (1977), Perry *et al.* (1979), and Atkinson *et al.* (1999) did not delineate such a zone. Stanford and Zimmerman (1978), Stanford *et al.* (1977), Perry *et al.* (1979), and Atkinson *et al.* (1999) all indicate that chloride and sulfate concentrations are highest in the Upper Red River Zone and are more variable than in other zones. The Red River Transition Zone shows decreasing concentrations from west to east and is influenced by loadings from Big Mineral Creek. The Main Lake Zone is relatively homogenous in surface layers in terms of chlorides and sulfates and shows much less variability than the other zones. The Washita River Arm is lowest in its concentration of chlorides and sulfates but shows considerable variability attributable to fluctuating loadings from the Washita River.

Temporal (seasonal) variability of chlorides and sulfates in the four zones appears to be a direct function of discharge from the Red River and the Washita River. Maximum chloride concentrations in the Upper Red River Zone are typically observed during seasons of low discharge (winter and late summer) and minimum chloride concentrations are generally observed following late spring/early fall periods of high discharge. By contrast, chloride loadings were maximal during high discharge periods and lower during low discharge periods. Atkinson *et al.* (1996) determined that the influence of river discharge was most apparent in the zones proximate to each river and less apparent in the Main Lake Body Zone based on historical water quality studies. Stanford and Zimmerman (1978), Stanford *et al.* (1977) Perry *et al.* (1979) found that late spring/early summer periods of high river discharge only occurred in the latter 2 years of their 3-year monitoring period, indicating a considerable degree of inter-annual variability. The degree to which inter-annual variability and river discharge can influence all zones of the lake was observed in the Main Lake Zone in August 1996 when chloride concentrations there were comparable to chloride concentrations in the Red River Zone (423 mg/l and 535 mg/l, respectively) (Atkinson *et al.*, 1999) following a period of increased discharge from the Red River.

Additional studies addressing the spatial and temporal variability of Lake Texoma water quality parameters were examined by contrasting the results of Stanford and Zimmerman (1978), Stanford *et al.* (1977), and Perry *et al.* (1979) to three other studies: Pettitt (1976), USACE (1989), and Matthews and Hill (1988). A comparison of chloride and sulfate data from Pettitt's study conducted December 2-3, 1975, with results of the Stanford *et al.* December 18-20, 1975 study showed similar zonational trends in the lake but consistently higher chloride and sulfate concentrations in early December (Pettitt) versus late December (Stanford *et al.*). This comparison demonstrates the variability that can exist between two sets of data collected in the same month at similar locations.

Comparing water quality results from the USACE study conducted in 1987 through 1989 in the Rock Creek tributary to results from a similar station gathered by from Stanford and Zimmerman (1978), Stanford *et al.* (1977), and Perry *et al.* (1979) showed considerably lower chloride and sulfate concentrations in Rock Creek during the 1987-1989 study versus the 1975-1978 study. However, comparisons between the USACE (1989) study and the Atkinson *et al.* (1999) study indicates that chloride concentrations in Rock Creek have increased slightly in the 1990s, and that sulfate concentrations have increased to levels comparable to those present in the 1970s.

A third study by Matthews and Hill (1988) in the summer of 1982 and 1983 provides insight into the behavior of vertical stratification in Lake Texoma. Comparing results from their study to the 1975-1978 study demonstrated that the deep sample sites showed similar patterns of stratification. Stations in the Main Lake Body developed a relatively stable thermal stratification during early summer months (May-June) of 1976-1978. Thermal stratification did not exhibit a sharp thermocline in the traditional sense but apparently was stable enough to isolate the hypolimnion long enough to develop anoxic conditions. During summer conditions, establishment of a "traditional" thermocline does not appear to occur in the transition zones of either the Red River or the Washita River arms. Instead, a gradual decrease of temperature with depth occurs with surface temperatures of approximately 32 ^{o}Celsius (C) and bottom temperatures around 20 ^{o}C.

A "chemocline" based on dissolved oxygen and pH appears to gradually develop around a depth of 10 meters. Below the "chemocline", dissolved oxygen is low (< 2.0 mg/l) indicating that much of the hypolimnion is relatively anoxic. Vertical stratification of inorganic salts is not as distinctive as that of oxygen and pH. There appeared to be a general increase in specific conductance in the hypolimnion but no distinct zone of demarcation in the Red River arm (Matthews and Hill, 1988). Data from the 1975-1978 study (Stanford and Zimmerman 1978; Stanford *et al.* 1977; and Perry *et al.*1979) indicated that during that period the lake exhibited similar vertical gradients in temperature, dissolved oxygen, and pH, but that vertical gradients of specific conductance were more sporadic with higher values in the epilimnion and lower values in the hypolimnion.

Several factors have been reported to influence the vertical stratification of Lake Texoma. Hubbs *et al.* (1976) reported the presence of a "halocline" in the Red River arm of the lake below which total dissolved solids were found to substantially increase. During periods of stratification, "halocline" development would begin in the old river channel of the Red River in early summer and then move out into the old floodplain during extended periods of "warm, quiet weather" (Hubbs *et al.*, 1976). Matthews and Hill (1988) concluded that although chemical gradients are present in the lake during periods of stratification, these chemical gradients (e.g., salinity) do not contribute to stratification stability to the degree that water temperature does. In contrast, using techniques described by Matthews and Hill (1988), Clyde (unpublished data) evaluated stratification intensity and stability data during two separate study periods (August 1996 - September 1997 and March 1999 - March 2000). Analysis of thermal and salinity density differences across the epilimnion-hypolimnion boundary in the summer of 1997 and 2000 indicated that both thermal and salinity densities contributed equally to stratification stability. Although there was no clear spatial trend in thermal versus salinity stratification stability, a temporal trend was evident and appeared to be correlated with discharge from the Red River.

2. <u>Aquatic Invertebrates</u>. Atkinson *et al.* (1999) analyzed zooplankton samples collected between August 1996 and September 1997. The zooplankton community in Lake Texoma during this study consisted of 72 species within 39 genera. The Rotifera exhibited the largest number of species (44) and the Harpacticoida the smallest number of species (1). Of the remaining crustacean species, the Cladocera exhibited the largest number of species (18) followed by the Cyclopoids (6) and the Calanoids (3). Historically, 28 zooplankton species had been reported from the lake (Crist, 1980). A comparison of the Atkinson *et al.* (1999) study with the Crist (1980) study revealed that the most dramatic change in the zooplankton community was due to the addition of new Cladoceran species. Within the Cladoceran group three new genera were identified (i.e., *Alona, Chydorus¸* and *Leydigia*), as well as new species identifications within the genera *Ceriodaphnia* and *Moina*. Within the genus *Daphnia*, four new species were identified in samples taken from Lake Texoma (i.e., *D. lumholtzi, D. longiremis, D. pulex, D. cawtaba*).

J. Franks (2000) addressed the relationship between zooplankton populations and physical/chemical water characteristics from August 1996 to September 1997. The results of the study indicated that a strong chloride gradient exists within the lake as well as a weaker turbidity gradient. This conclusion has been confirmed by other studies as well (Atkinson *et. al.* 1996). Physical-chemical factors alone were found to explain on average 90% more of the variation in the zooplankton community than seasonal factors. The Red River arm of the lake was found to exhibit the greatest zooplankton density as well as the greatest diversity. This same pattern was reported by Crist (1980). However, the two contributing river systems, including the Red River and Washita River, though varying by an order of magnitude in chloride concentrations, each harbor significant populations of zooplankton which contribute to lake conditions.

Temporal variability in zooplankton abundance followed the typical seasonal pattern represented by a major pulse in the spring (May and June) and a second smaller pulse in the fall (September) as zooplankton populations recovered from the summer die-off. Zooplankton densities, as well as species diversity (i.e., Shannon diversity index), were greatest in the Red River and Washita River arms and generally tended to decrease through the transitional zones and Main Lake Zone. Analysis of community similarity (i.e., Bray-Curtis Similarity Index) between the reservoir zones revealed that within each arm of the lake (i.e., Red River and Washita River), species composition was similar between the river zone and transition zone, and the species composition in the Main Lake Zone was similar to the Red River Transition Zone twice as often as it was similar to the Washita River Zone.

3. Fish Resources of Lake Texoma. A description of fishery resources in Lake Texoma was prepared Wilde, *et al.*, (1996). Lake Texoma provides habitat for at least 73 species of fish (University of Tulsa 1971). Species popular for recreation and fishing include channel, blue, and flathead catfish; white and black crappie; temperate basses such as largemouth, smallmouth, and spotted bass; and true basses including white and striped bass. Gizzard shad, threadfin shad, and inland silversides are important forage species in the lake. Drum, carp, gar, buffalo, and river carpsucker make up the bulk of the non-game fish in the lake. An important tailwater fishery also exists for striped bass and channel, blue, and flathead catfish. The striped bass and smallmouth bass fisheries were developed in Lake Texoma after the initial FES (1976) was prepared for the RRCCP.

Reservoir strain smallmouth bass were stocked in Lake Texoma in 1981, and natural reproduction was confirmed in 1985 (Hysmith 1988). Since that time, populations have been expanding and growth rates have equaled or exceeded most of those reported in the literature (Gilliland and Horton 1989).

Striped bass were initially stocked in Lake Texoma by the ODWC from 1965 until 1974 (Harper and Namminga 1986) and have successfully spawned annually since 1973 (Mauck 1991). Since the initial stocking, the striped bass fishery in Lake Texoma has developed into an extremely popular fishery and is considered one of the most successful striped bass fisheries in the nation (U.S. Fish and Wildlife Service 1989). Mauck (1991) estimated that from 1987 through 1990, the annual harvest of striped bass ranged from 630,000 to 930,000. The abundance and size of the striped bass has varied between specific years in response to strength of year classes and availability of forage species.

Striped bass are known to spawn in both the Washita and Red rivers and in the Red River striped bass have been caught near Spanish Fort, Texas which is greater than 30 miles upstream from the I-35 bridge upstream from Lake Texoma. Viable striped bass eggs floating down the Red River have been collected at the I-35 bridge. As discussed previously, under existing conditions, the salinity of the Red River flowing into Lake Texoma exceeds 500 mg/l, 95% of the time and 250 mg/l, 99% of the time. These high salinity concentrations may affect striped bass usage of the Red River.

An economic study and analysis of the value of the Lake Texoma sport fishery indicated that the indirect and direct effect of angler expenditures is $28.1 million, with striped bass fishing accounting for over 60% of the expenditures (Schreiner 1995). This reported maximum value of the fishery represents 0.8% of the income of the seven-county region and indicates that angler expenditures associated with the Lake Texoma sport fishery have an insignificant effect on the region's overall economy.

Vertical stratification in Lake Texoma is well documented (Schorr *et al.* 1993, Matthews and Hill 1988, and Hubbs *et al.* 1976). Stratification has a negative impact on freshwater species, especially striped bass. Striped bass have narrow tolerance ranges for dissolved oxygen and temperature. During periods of stratification, striped bass concentrate near the themocline where dissolved oxygen levels are low and this can result in summer die-offs (especially larger fish) due to stress induced by stratification. The ODWC has reported that smaller stripers are not as readily subjected to thermal stress and this tolerance allows them to occupy the shallow upper reaches of the reservoir during the summertime.

4. Recreation. Lake Texoma is located within Texas Planning Region 22 (Texoma). Region 22 is composed of three counties totaling 2,699 square miles, and the population for this region in 2000 was 178,200. According to the 1990 TORP, it has 44,844 acres of recreation land, 6,874 acres of developed recreation areas, and 92,713 surface-acres of water. The TORP lists water resources and developed recreation land as Region 22's most abundant assets. The region ranked the highest in acres per thousand people for the state in 1990. Additional outdoor recreational facilities/resources needed in this region include boat ramp lanes, fishing structures, hiking trails, horseback riding trails, team sport facilities, swimming, tennis courts, and multi-use trails.

Lake Texoma is located within Oklahoma Planning Region 4 (Southern Oklahoma Development Association). This planning region is composed of 10 counties having an area of 4,293,760 acres. The total population in 2000 was 209,569. It has a number of rivers and land recreation opportunities, as well as significant water resources. According to the 1987 Oklahoma Statewide Comprehensive Outdoor Recreation Plan (SCORP), Region 4 has a well-developed recreation base; however, the SCORP identifies needs for tennis courts, golf courses, swimming pools, bicycling and horse riding trails, and additional hunting areas.

Lake Texoma is widely recognized as a top fishing lake, primarily for striped bass, and is one of the most popular recreational destinations in the southwestern United States. Recreational opportunities include camping, fishing, hunting, waterskiing, swimming, jet skiing, hiking, horseback riding, and wildlife watching (USACE 2002).

The USACE manages 54 parks on the lake including 40 miles of equestrian/hiking trails, 15 campgrounds for a total of 800 campsites near the lake, and other water-related activities. Two State Parks, two National Wildlife Refuges, and several local parks are also located on the lake and provide recreational activities (USACE 2002).

Eisenhower State Park, located in Grayson County, Texas on the southern portion of Lake Texoma, provides picnic sites, five camping areas with 165 campsites, restrooms, a recreation hall, a fish-cleaning facility, a boat launching ramp, a courtesy boat dock, a lighted fishing pier, and 4.5 miles of hiking and mountain biking trails. Lake Texoma State Resort Park, located in Marshall County, Oklahoma on the northern portion of Lake Texoma, provides a resort lodge, cottages, three camping areas with 517 campsites, an RV rally group campground, a nature center, an indoor fitness and recreation center, a swimming beach and pool, a miniature golf course, a go-cart track, two 18-hole golf courses, an air strip, and hiking trails.

The Hagerman National Wildlife Refuge, located in Grayson County, Texas, on the southern portion of Lake Texoma, offers fishing, bird watching, hiking, interpretive trails, nature study, and limited hunting of deer, dove, quail, squirrel, rabbit, and feral hogs. The Tishomingo National Wildlife Refuge, located in Johnston County, Oklahoma, on the northern portion of Lake Texoma, offers fishing, bird watching, hiking, nature trails, and limited hunting of waterfowl, deer, dove, rabbit, squirrel, quail, and turkey.

As previously mentioned, Lake Texoma is well known for its sport fishing. Sport fish occupying the lake include largemouth, spotted, and smallmouth bass, white bass, striped bass, walleye, white crappie, black crappie, channel catfish, flathead catfish, blue catfish, bullhead, and sunfish. Approximately 30 fishing guide services are available on the lake that offer a variety of guided trips on the lake.

The 26 marinas and resorts located near the lake offer a variety of recreational activities including RV and tent camping, fishing and fishing supplies, motor boat, sailboat and watercraft rentals, canoe rentals, swimming beaches, tennis courts, horseback riding, restaurants, and hiking trails.

5. Water Supply. As a water supply, Lake Texoma serves north Texas and south-central Oklahoma. The total water supply storage available is about 158,060 acre-feet, with a dependable yield of 150 million gallons per day (mgd). Water supply storage in Texoma Lake is under contract to specified users as shown in Table 3-17.

TABLE 3-17
LAKE TEXOMA WATER SUPPLY ALLOCATIONS

User	Allocated Storage (Acre-Feet)	Yield (mgd)
City of Denison	21,300	20.224
TX Power & Light	16,400	15.564
Red River Valley	2,736	2.597
North Texas MWD	95,023	90.178
Buncombe Creek	1	.001
GTUA f/Sherman	11,000	10.433
Not Under Contract	11,600	11.003
Total	158,060	150.0

In 1986, Section 838 of Public Law 99-662 gave the USACE the authority to reallocate an additional 300,000 acre-feet of hydropower storage to water supply. This authority did not preclude all the NEPA, cultural, and socio-economic studies necessary to change storage from one project purpose to another. Of the 300,000 acre-feet, 150,000 acre-feet is for Texas and of that 150,000 acre-feet the Greater Texoma Utility Authority (GTUA) is granted the use of 50,000 acre-feet. The other 150,000 acre-feet is allocated to Oklahoma. In FY 2002, a study was initiated to start the reallocation process of the 300,000 acre-feet of storage.

In 1990, the Lake Texoma Advisory Committee was established by Public Law 100-71. The purpose of the Committee is advisory only and shall provide information and recommendations to the USACE regarding the operations of Lake Texoma for its congressionally authorized purposes.

6. Denison Dam Hydropower. The powerhouse contains two 35,000-kilowatt generators, with provisions for three additional 43,000-kilowatt units. One 20-foot-diameter, steel-lined conduit provides water for each power unit. Each of the power conduits is equipped with two 9- by 19-foot vertical life gates located in the intake structure. The powerhouse and power conduits are located adjacent to the outlet works near the right abutment of Denison Dam.

At full power pool, Lake Texoma has 103.2 feet of water depth available for power production. Section 838(a) of the Water Resources Development Act of 1986 (Public Law 99-662) authorizes the Secretary of the Army to reallocate an additional 300,000 acre-feet of hydropower storage to water supply which could affect the pool volume available for long-term power supply. The lake's current dependable capacity for the hydropower production is rated at 54,000 kW, with an average annual firm energy output of 126,470,000 kW-hrs .

g. Other Recreational Resources.

1. Crowell Mitigation Area/Copper Breaks State Park. The Crowell Mitigation Area encompasses approximately 10,000 acres and is located within Texas Planning Region 3. The mitigation area is immediately south of Copper Breaks State Park, approximately 7 miles north of Crowell, Texas. The State Park includes a small fishing lake, visitor center, campsites, and hiking trails. The lake is used as a warm water fishery during warmer months and is stocked with rainbow trout during winter months to provide a put-and-take trout fishery. The Crowell Mitigation Area would provide additional recreation opportunities including both consumptive and non-consumptive activities. These activities would include fishing, hunting, sightseeing, hiking, and nature photography.

2. Matador Wildlife Management Area. In Cottle County, the TPWD administers the 28,183-acre Matador Wildlife Management Area where public hunting for dove and quail is permitted. On this refuge, the demand for quail hunting is such that a permit drawing system must limit it. Extensive upland game habitat provides the potential for expanded hunting activity, although such expansion would require greater hunter access to private farm and ranch lands or additional public lands being opened to hunting.

3. Texas Planning Region 2. Texas Planning Region 2 (South Plains) is composed of 15 counties totaling 13,605 square miles. The South Fork of the Wichita River is located in Region 2. According to the U.S. Census Bureau, the population for Region 2 in 2000 was 377,871. According to the 1990 TORP, Region 2 ranks well below the statewide average for acres of recreation land per capita. Region 2 has 21,749 acres of recreation land in 211 parks, averaging 53 acres of recreation land per thousand people. This includes a total of 5,803 acres of developed recreation land and 2,673 surface acres of lakes. Projected outdoor recreation facilities/resources needed include freshwater swimming, horseback-riding trails, softball fields, playground areas, campsites, off-road vehicle riding areas, and multi-use trails.

4. Southern Oklahoma Development Association Region 9. Southern Oklahoma Development Association Region 9 is composed of eight counties having an area of 4,648,320 acres. The total population in 2000 was 278,400, with a household population of 101,279. The primary outdoor recreation resource is the Wichita Mountains Wildlife Refuge. Water-based recreational facilities and state parks and recreations areas are limited. The Oklahoma SCORP identified needs in the area for basketball, tennis, golf, swimming, bicycling, hunting and fishing areas, canoeing, and horseback riding facilities.

4 ENVIRONMENTAL IMPACTS OF PROPOSED ACTION.

Detailed descriptions of potential project impacts were documented in Section 4 of the 1976 FES. This section addresses only impacts associated with project design changes, new issues or concerns that have arisen since the FES was filed, and the alternative identified as 7a in Section 2 of this document. To assist in identification, evaluation, and comparison of impacts, a base map was developed that divides the study area into specific hydrologic reaches (Figure 3-1).

An impact assessment matrix delineating potential environmental consequences of the proposed project is presented in Table 4-1. Potential impacts on natural resources, social values, economic benefits, and cultural resources were carefully considered and the magnitude of projected impacts listed in the table. A discussion of these impacts follows:

a. Potential Impacts Removed from Further Consideration. Consideration of impacts to air quality, wild and scenic rivers, environmental justice, noise, and soils were not applicable in analysis of the project as described in the following sections. These topics were therefore removed from further discussion.

1. Air Quality. The only potential air pollution problem associated with the project would be temporary periods of fugitive dust during construction and operation and maintenance (O&M) activities, such as road repair or grading. Pump motors to be used at each intake are electrically powered and would produce no emissions. The project would comply with the EPA's Conformity Rule, which requires all Federal actions to conform to State Implementation Plans (SIPs) to improve ambient air quality. The Conformity Rule requires a conformity determination based on air emission analyses for each proposed Federal action within a non-attainment area. At this time, the Conformity Rule only applies to Federal actions in non-attainment areas; therefore, a conformity determination is not required. In the event an air permit were required for a concrete batch plant or similar facility, the contractor would be responsible for compliance. For these reasons, this issue has been removed from further consideration.

2. Wild and Scenic Rivers. The list of wild and scenic rivers as well as the listing of potential additions has been reviewed. The Wichita River and Upper Red River were not found to be included. In addition, it should be noted that the proposed project components (as part of the RRCCP) were authorized by Congress and were under construction prior to passage of the Wild and Scenic Rivers Act. Section 5(d) of the Act requires that the Secretary of the Interior and the Secretary of Agriculture study and investigate to determine which additional wild, scenic and recreational river areas should be evaluated for planning purposes. To date, such studies have not been completed for the Wichita River or Red River. Therefore, this item has been removed from further consideration.

3. Environmental Justice. Environmental justice has been defined as the pursuit of equal justice and equal protection under the law for all environmental statutes and regulations without discrimination based on race, ethnicity, or socioeconomic status. With respect to the proposed plan, overall populations and racial/socioeconomic groups would be affected equally in terms of beneficial impacts. Adverse impacts, while localized, would not affect human populations. Furthermore, public participation and education have been key aspects of this Reevaluation. Therefore, this item has been removed from further consideration.

TABLE 4-1
IMPACT SUMMARY BY ISSUE AND REACH FOR PROPOSED PLAN

Issue Evaluated	Hydrologic Reach (Figure 3-1)								
	11	10	9	Truscott	Kemp	8	7	6	5
Air Quality	NA	NA	NA	NA	NA	NA	NA	NA	NA
Wild and Scenic Rivers	NA	NA	NA	NA	NA	NA	NA	NA	NA
Environmental Justice	NA	NA	NA	NA	NA	NA	NA	NA	NA
Noise	**NAE**	**NAE**	NA	NA	NA	NA	NA	NA	NA
Soil	**NAE**	**NAE**	NA	**NAE**	NA	NA	NA	NA	NA
Hazardous, Toxic and Radiological Waste (HTRW)	**NAE**	**NAE**	NA	**NAE**	NA	NA	NA	NA	NA
Terrestrial Resources									
Vegetation	**B1**	**B1**	**B1**	**A1**	**NAE**	**NAE**	NA	**NAE**	**NAE**
Wildlife	**B2**	**B2**	**B2**	**NAE**	**B1**	**NAE**	NA	**NAE**	**NAE**
Construction	**A1**	**A1**	NA	**A2**	NA	NA	NA	NA	NA
Nutrients and Contaminants	NA	NA	NA	NA	NA	**A1**	**A1**	**A1**	**NAE**
Floodplains and Wetlands	**NAE**	**NAE**	**NAE**	**NAE**	**NAE**	**NAE**	NA	**NAE**	**NAE**
Water Supply	NA	NA	NA	NA	**B3**	**B3**	NA	**B1**	**B1**
Threatened and Endangered Species									
Construction	**NAE**	**NAE**	NA	**NAE**	NA	NA	NA	NA	NA
Selenium at Truscott	NA	NA	NA	**NAE**	NA	NA	NA	NA	NA
Land Use Changes	**NAE**	**NAE**	**NAE**	**NAE**	**NAE**	**NAE**	**A1**	**NAE**	**A1**
Nutrients and Contaminants	NA	NA	NA	NA	**NAE**	**A1**	**A1**	**A1**	**NAE**
Agriculture	NA	NA	NA	NA	NA	**B3**	**B2**	**B1**	**NAE**
Cultural Resources									
Area VII	NA	**U**	NA	**U**	NA	NA	NA	NA	NA
Area VIII	**U**	NA	NA	**U**	NA	NA	NA	NA	NA
Area X	NA	**U**	NA	**U**	NA	NA	NA	NA	NA
Wichita River									
Stream Water Quality – Chlorides	**B3**	**B3**	**B3**	NA	**B3**	**B3**	NA	NA	NA
Stream Water Quality – Nutrients/Pesticides	**NAE**	**NAE**	**NAE**	NA	NA	**A1**	NA	NA	NA
Selenium	**B2**	**B2**	**B1**	NA	**B1**	**NAE**	NA	NA	NA
Flow	**A1**	**A1**	**NAE**	NA	**NAE**	**NAE**	NA	NA	NA
Upper Wichita River Fish Communities									
Species Isolation	**NAE**	**NAE**	**NAE**	NA	NA	NA	NA	NA	NA
Flow Alteration	**A1**	**A1**	**A1**	NA	NA	NA	NA	NA	NA
Salinity Reduction	**A1**	**A1**	**A1**	NA	NA	NA	NA	NA	NA
Lower Wichita River Fish Communities	NA	NA	NA	NA	**A1**	**NAE**	NA	NA	NA
Truscott Reservoir									
Chloride	NA	NA	NA	**A3**	NA	NA	NA	NA	NA
Selenium Levels	NA	NA	NA	**B1*/A3****	NA	NA	NA	NA	NA
Lake Volume	NA	NA	NA	**U**	NA	NA	NA	NA	NA
Upper Red River									
Stream Water Quality – Chlorides	NA	NA	NA	NA	NA	NA	**B1**	**B1**	**B1**
Stream Water Quality – Nutrients/Pesticides	NA	NA	NA	NA	NA	NA	**A1**	**A1**	**NAE**
Selenium	NA	NA	NA	NA	NA	NA	**NAE**	**NAE**	**NAE**
Flow	NA	NA	NA	NA	NA	NA	**NAE**	**NAE**	**NAE**
Fish Communities	NA	NA	NA	NA	NA	NA	**NAE**	**NAE**	**NAE**
Lakes Kemp & Diversion									
Reservoir Water Quality									
Chloride	NA	NA	NA	NA	**B3**	NA	NA	NA	NA
Nutrient Cycling	NA	NA	NA	NA	**U**	NA	NA	NA	NA
Turbidity	NA	NA	NA	NA	**A1**	NA	NA	NA	NA
Plankton Dynamics	NA	NA	NA	NA	**U**	NA	NA	NA	NA
Dundee Hatchery	NA	NA	NA	NA	**NAE**	NA	NA	NA	NA
Flow to Lakes									
Future Use	NA	NA	NA	NA	**A1**	NA	NA	NA	NA
Drought Contingency	NA	NA	NA	NA	**A1**	NA	NA	NA	NA
Dundee Fish Hatchery	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 4-1 (Continued)

Issue Evaluated	**11**	**10**	**9**	**Truscott**	**Kemp**	**8**	**7**	**6**	**5**
Kemp Fish Communities									
Fish Habitat	NA	NA	NA	NA	**A1**	NA	NA	NA	NA
Diversion Fish Communities									
Water Quality	NA	NA	NA	NA	**NAE**	NA	NA	NA	NA
Fish Habitat	NA	NA	NA	NA	**NAE**	NA	NA	NA	NA
Recreation	NA	NA	NA	NA	**NAE**	NA	NA	NA	NA
Lake Texoma									
Reservoir Water Quality									
Chloride	NA	NA	NA	NA	NA	NA	NA	NA	**B1**
Turbidity	NA	NA	NA	NA	NA	NA	NA	NA	**NAE**
Nutrient Cycling	NA	NA	NA	NA	NA	NA	NA	NA	**NAE**
Plankton Dynamics	NA	NA	NA	NA	NA	NA	NA	NA	**NAE**
Fish Communities	NA	NA	NA	NA	NA	NA	NA	NA	**NAE**
Recreation	NA	NA	NA	NA	NA	NA	NA	NA	**NAE**
Hydropower	NA	NA	NA	NA	NA	NA	NA	NA	**NAE**
Land Use Changes									
Area VII	**A3**	NA	NA	NA	NA	NA	NA	NA	NA
Area VIII	NA	**A3**	NA	NA	NA	NA	NA	NA	NA
Area X	**A3**	NA	NA	NA	NA	NA	NA	NA	NA
Truscott Brine Disposal Reservoir	NA	NA	NA	**A2**	NA	NA	NA	NA	NA
By Reach	**NAE**	**NAE**	NA	**A2**	NA	**NAE**	**NAE**	**NAE**	**NAE**
Economic Impacts									
Above Lake Kemp	**NAE**	**NAE**	**NAE**	NA	NA	NA	NA	NA	NA
Between Kemp and Texoma	NA	NA	NA	NA	NA	**B1**	**B1**	**B1**	NA
Adjacent to Lake Kemp	NA	NA	NA	NA	**NAE**	NA	NA	NA	NA
Adjacent to Lake Texoma	NA	NA	NA	NA	NA	NA	NA	NA	**B1**
Cumulative Impacts									
Lake Texoma Productivity	NA	NA	NA	NA	NA	NA	NA	NA	**NAE**

Legend	Magnitude of Probable Impact
NA	Not Applicable
NAE	No Appreciable Effect
A1	Minor Adverse Impact
A2	Substantial Adverse Impact
A3	Significant Adverse Impact
B1	Minor Beneficial Impact
B2	Substantial Beneficial Impact
B3	Significant Beneficial Impact
U	Unquantifiable (may have positive or negative impacts) or Additional Work Required

*Duration that concentrations in bird prey (e.g. fish, invertebrates) are less than those in surrounding aquatic systems (see text)
** Should concentrations ever reach impact levels for birds (see text)

4. Noise. Facilities that would be constructed as part of the proposed plan include large engines. However, these engines would be housed within large above-ground concrete vaults which would attenuate noise produced. The engines would be electrically powered to further minimize the potential for noise production. Finally, the proposed project construction sites are generally absent of receptors except for local fauna. Due to a lack of noise generation and noise receptors, this item has been removed from further consideration.

5. Soil. The proposed project would have no impact on soils within the project area. The Farmland Protection Policy Act, Subtitle I of Title XV of the Agriculture and Food Act of 1981, Public Law 97-98, establishes criteria for identifying and considering the effects of Federal programs on the conversion of farmland to non-agricultural uses and identifying technical assistance to agencies of State, Federal, and local governments. Section 1540(c)(4) of the Act exempts projects that were beyond the planning stage and were either in the active design or the construction state on the effective date of the Act. Since the authorized project was in the

construction phase, it is exempted from the Act, which includes preparation and coordination of the Farmland Conversion Impact Rating Form.

6. Hazardous, Toxic, and Radiological Waste (HTRW). An assessment of the potential for encountering HTRW on all lands associated with the proposed plan was conducted by the USACE. Based on results of this survey, it appears that the potential for encountering significant HTRW-related problems during the proposed project's implementation would be minimal.

b. Terrestrial Resource Impacts. The following section identifies and describes potential impacts to terrestrial resources (i.e., wildlife and vegetation). Public and agency issues identified during scoping included impacts to wildlife/vegetation species and habitat, and potential impacts caused by site location, structures, and construction and operational activities associated with the proposed project.

1. General Impacts. General impacts are those not caused by specific or time-limited events. These impacts would be characteristic of the proposed project duration.

(a) Vegetation. Saltcedar (*Tamarix chinensis*) has become established and dominates the riparian vegetation in many areas of the Wichita River Basin. Encroachment by saltcedar is detrimental because this plant tends to form monocultures having little value for fish or wildlife. Species richness, diversity, and density would be increased in the project study area if saltcedar were less abundant in the riparian zone.

Studies conducted by the University of Oklahoma (1975) concluded that the project would not have a significant impact on terrestrial vegetation. However, with improved water quality, a slow change in riparian vegetation should occur. Streamside plants, which tolerate a higher salinity environment, would eventually have to compete with species that are less tolerant of high salinities. Consequently, over time, species such as willows, cottonwoods, and other bottomland species may invade sites now dominated by salt cedar and other more salt tolerant species. Monitoring of riparian areas would occur, as described in the EOP (Appendix A), to evaluate these potential habitat changes.

(b) Wildlife. The Wichita River Basin is approximately 3,485 square miles in north central Texas (Figure 1-1). There are no exceptional wildlife resources known to occur in the general area. Primary impacts on faunal communities would result from reduced salinity and stream flows. Generally, the species adapted to high salinity would be replaced by less salt tolerant species resulting in greater species richness and diversity. These changes would be seen in the upper Wichita River tributary streams (Reaches 9, 10 and 11) where brine withdrawals constitute a larger portion of the total flow. While these reaches of the Wichita River are currently unusable for wildlife, in terms of a drinking water resource, the proposed project would benefit terrestrial wildlife by providing a drinkable water source. Within the lower reaches of the project (Reaches 6, 7 and 8) the effects of this project on water quality, and hence terrestrial wildlife, would be less noticeable.

(c) Nutrients and Contaminants. Associated with an increase in agricultural irrigation, the potential exists for an increase in levels of nutrients and pesticides, while levels of herbicides may decrease. The exact amounts and implications of these potential changes in water quality on some wildlife species and other terrestrial resources are not known and would be difficult to ascertain. Based upon the best available information and assessment of the known impacts of the proposed project, construction and operation of the proposed project has the potential to increase levels of nutrients and pesticides, which could adversely impact some wildlife species and/or other terrestrial resources in Reaches 6, 7, and 8 and downstream.

2. Construction Activities. The majority of construction activities would be confined to the upper (western) portion of the Wichita River Basin, while most of the benefits from the proposed project would be recognized throughout the Wichita River Basin and to a lesser extent on the Red River from the confluence of the Wichita River downstream to Lake Texoma. The majority of construction impacts would be due to potential future expansion of the brine storage reservoir, in 75-100 years. The Truscott Brine Disposal Reservoir has already been constructed and has been operational since 1987. The proposed plan would require modifications of the dam at Truscott Reservoir to create a larger volume brine disposal lake than what is currently present. The brine pool and project facilities would result in the loss of approximately 3,515 acres of terrestrial habitat/plant communities, with the majority being mesquite-juniper grassland at Truscott Brine Disposal Reservoir. However, implementation of this phase is not anticipated to occur until approximately 75 years into the proposed project.

Terrestrial resources would also be impacted on a temporary basis by the construction of pipelines associated with the proposed project. Pipelines would be constructed to convey collected brines from Area VII and Area X to Truscott Brine Disposal Reservoir. These impacts would be temporary in nature. A portion of the pipeline easements would be graded but the remainder would be allowed to return to its natural state. At the inlet and/or outlet of the pipelines, spray fields would be constructed to reduce brine volume. Additional terrestrial resources would be lost due to construction of Area VII brine collection facilities. Terrestrial resource losses resulting from construction of the spray fields and Area VII would be a permanent loss of approximately 528 acres consisting primarily of mesquite-juniper grassland.

Short-term impacts from human activity disturbing wildlife during construction would likely occur in some areas, but should not have any significant effect on wildlife populations. Mitigation for permanent terrestrial habitat losses has been established at the Crowell Brine Lake Area and is addressed in the Mitigation Plan (Appendix B).

c. Floodplains and Wetlands. Concern has been expressed regarding conversion of riparian areas to farmland. The majority of farmland conversion, primarily in Reaches 6, 7, and 8, would convert dryland farming to irrigated farming, rather than riparian areas to farmland. Although there is a potential for some conversion of non-cropland riparian zones to irrigated cropland, the extent and location of these areas are unknown and speculative. In addition, conversion of wetlands to cropland is prohibited by the RRA and the Wichita County Water Improvement District No. 2.

Future riparian resource protection may also occur as a result of management by the BLM, which would prevent future conversion to agriculture. The BLM is the Federal management agency responsible for public domain lands in the study area. Riparian zone protection, including wetland restrictions on most transfer patents issued for public land tracts along the north bank of the Red River, is listed as a management consideration in the Record of Decision for the Proposed Oklahoma Resource Management Plan (OK-RMP). According to the Record of Decision for the BLM's OK-RMP, signed January 1994, this scenario would result in approximately 90,000 total acres being addressed as possible public domain.

A Section 404 evaluation and a Statement of Findings (SOF) for Areas VII and X were completed and signed May 13, 1977. A Section 404 evaluation and an SOF for Area VIII were signed March 16, 1977. Brine pipeline creek crossings and outfall structures are within the scope of Nationwide Permits issued pursuant to Section 404. No project-specific Section 404(b)(1) compliance review would be required for features of the proposed plan.

The proposed low-flow control structures, pipelines, and other features of the chloride control project would be designed and constructed so that there is no significant increase in flood hazards. Flow diversion structures, by virtue of their very purpose, must be in potentially flood-prone areas but must resist damage by flooding. Pump stations and other pertinent features of the project would be elevated above or protected from the 100-year frequency flood. Accordingly, the proposed project would be in compliance with Executive Order (E.O.) 11988, Floodplain Management.

d. Water Supply. One of the benefits of the proposed project would be improved water quality such that it may be economically feasible for municipal, industrial and agricultural water supply. Surface and groundwater sources to meet the current and future economic growth within the Wichita River Basin are reaching their maximum dependable limits. The City of Wichita Falls is a major water supplier within the region and currently provides water to several surrounding cities, water districts, industry and agriculture in addition to its own uses. Because of the extended drought conditions being experienced in the region, water from the Lake Kemp-Diversion system is currently intended for supplemental use with Arrowhead and Kickapoo reservoirs within the next 3 years. Utilization of Lake Kemp, as modeled by the USACE, could add up to 61,222 acre-feet of water per year to the present municipal, industrial, and agriculture water supplies within the region.

Water quality benefits to municipal and industrial water supplies might also be realized at Lake Texoma. Economic benefits to municipal and industrial users are measurable as a result of even minor changes in water quality. Water quantity changes at Lake Texoma are not anticipated as a result of the proposed plan.

e. Threatened and/or Endangered Species. Impacts to threatened and endangered species and their habitat was identified as one of the key scoping issues. In accordance with Section 7 of the Endangered Species Act, and to conform with USACE regulations, a BA (USACE 2001d) has been prepared for this project, which address potential impacts to Federally listed endangered and threatened species. Section 3 of this document includes a summary of the BA, but most of the detailed information on these species is contained in the BA and included by reference at http//www.swt.usace.army.mil/LIBRARY/Library.CFM. A BA was prepared by the USACE and submitted to the USFWS in July, 2001. The USFWS subsequently issued their BO dated July 20, 2001. At that time, the USFWS stated that the proposed project should have no effect on threatened and endangered species.

Three species which have special status under both Federal and State of Oklahoma and Texas regulations, the bald eagle, the interior least tern and the whooping crane, are addressed primarily in the BA. Eight State of Oklahoma or Texas threatened and endangered species are addressed in this section.

1. Construction Impacts. Construction activities would be confined to the upper or western portion of the Wichita River Basin, while the benefits from the project (improved water quality) would be recognized throughout the Wichita River Basin and to a lesser extent on the Red River from the confluence of the Wichita River downstream to Lake Texoma. Currently there are no records or recent sightings of any of the three Federally-listed species within the project areas where construction activities are proposed for the collection facilities or pipeline routes. Least terns have been observed using Truscott Reservoir during spring and fall migrations. However, this species has not been known to nest at Truscott Reservoir. Consequently, construction activities associated with completing the collection facilities and pipelines should have little to no impacts on State listed species and no impacts on Federally listed species.

The proposed plan would require modification to the dam at Truscott Reservoir to create a larger volume brine disposal lake. Based on avian surveys conducted by Texas Tech University, (USACE 2001c) a small number of least terns utilize Truscott Reservoir on a limited basis during spring and fall migration periods. Modifications of Truscott Brine Disposal Reservoir would not require draining the lake, so the pool would remain intact for migrating least terns. During construction, there would be increased activities in the area of the dam that would probably cause terns to use the upper limits of the reservoir during the period of construction.

2. Selenium (Se) Levels in Truscott Reservoir. Aquatic birds are sensitive to Se in the aquatic environment. Their potential use of the brine disposal reservoir, and substantial information regarding impacts on these species were (and continue to be) the focus for a Se related impact evaluation for the project. The USACE completed a study entitled, "Alternatives for Chloride Control – Wichita River Basin and Truscott Brine Disposal Reservoir, TX", which is included in Appendix A of the BA at http://www.swt.usace.army.mil/LIBRARY/Library.CFM.

A detailed evaluation of impacts associated with Se can be found in the BA for this project. Based on the methodology and assumptions used for this evaluation of the Se-related concerns associated with brine disposal, it appears reasonable to assume that the proposed plan could be implemented without Se-induced impacts on non-breeding birds (e.g., wintering waterfowl) or significant Se-related sediment concerns for these species at Truscott Brine Disposal Reservoir, Texas. Modeled estimates of Se concentrations for the proposed plan are below estimated threshold values for non-reproductive impacts. Impacts on migrating least terns would therefore not be anticipated.

3. Land Use Changes. With the proposed project operational and improved water quality, there would be an increase in agricultural production and a noticeable shift in crop yields and cropping patterns on irrigable lands along the Wichita River and a portion of the Red River. As determined from the Texas A&M studies (2000, 2001), most of the agricultural changes are expected to occur from the conversion of dryland farming of Bermuda grass/hay to irrigated farming of alfalfa.

A detailed evaluation of impacts associated with acreages of land use changes can be found in the BA for this project. While the number of irrigated acres would increase, the conversion would come from other types of agricultural lands. Most of the irrigation would occur in economic reaches 5 and 7. Minor amounts are projected to occur in economic reaches 6 and 12. Conversion of existing agricultural land into irrigated agricultural lands should not impact State or Federally listed threatened and endangered species.

Land use changes in areas of native shrub/grassland habitat could negatively affect State-listed species such as the Texas kangaroo rat, timber rattlesnake, and Texas horned lizard. Completion of control structures at Areas VII, VIII, X, and Truscott Reservoir are anticipated to result in the loss of minor areas of mesquite-juniper uplands (4,417 acres out of 825,000 acres of mesquite-juniper in the Wichita Basin), which might affect these species. The majority of the land use change would be at Truscott Brine Disposal Reservoir. The creation of freshwater lakes at Truscott Brine Disposal Reservoir is also included in the estimate of mesquite-juniper habitat loss.

4. Nutrients and Contaminants. With an increase in irrigated lands, the potential exists for an increase in levels of nutrients and pesticides, while levels of herbicides may decrease. Nutrients and pesticides would be expected to increase with irrigated acreage due to runoff. Dryland farming typically requires the use of herbicides. Therefore, herbicides may decrease corresponding with reductions in sprayed acres of dryland agriculture. The exact amounts and implications of these potential changes in water quality on some wildlife species and other terrestrial resources are not known and currently unquantifiable. Based upon the best available

information and assessment of the known impacts of the project, construction and operation of the proposed project has the potential to increase levels of nutrients and pesticides in the lower reaches of the study area, which could adversely impact bald eagles, least terns, and whooping cranes as well as some State-listed species. State-listed species which could potentially be impacted include the snowy plover, blue sucker, blacksided darter, paddlefish, and shovelnose sturgeon.

f. Agriculture. One purpose of the proposed project is to provide an economically viable water supply for agricultural, municipal, and industrial uses. Impacts to agriculture, in terms of water supply and resulting crop yields, were evaluated in the Texas Agricultural Experiment Station report "Analysis of the Wichita River Portion of the Red River Chloride Control Study", dated September 2000. This study was updated in September 2001 by Texas A&M University. It should be noted that reaches in the Texas A&M study (Figure 4-1) varied from the hydrologic reaches as follows:

- Hydrologic reach 6 corresponds to economic reaches 5 and 6 on the Red River.
- Hydrologic reach 8 corresponds to economic reaches 7 and 12, Lake Diversion to the Red River.

Water for irrigation is currently available in reaches downstream of Lake Kemp/Diversion through the Wichita County Water Improvement District No. 2. In addition, water is available for irrigation along the Red River from the Wichita River confluence to Lake Texoma. Changes in irrigation requirements would be anticipated as a result of improved water quality.

If the proposed plan were implemented, water quality would improve such that less water would be required for irrigation. Due to improved water quality, less water would be required to leach excess salts from the soil, providing suitable soil conditions for plant growth. Based on water availability, more acres could be irrigated with improved water quality.

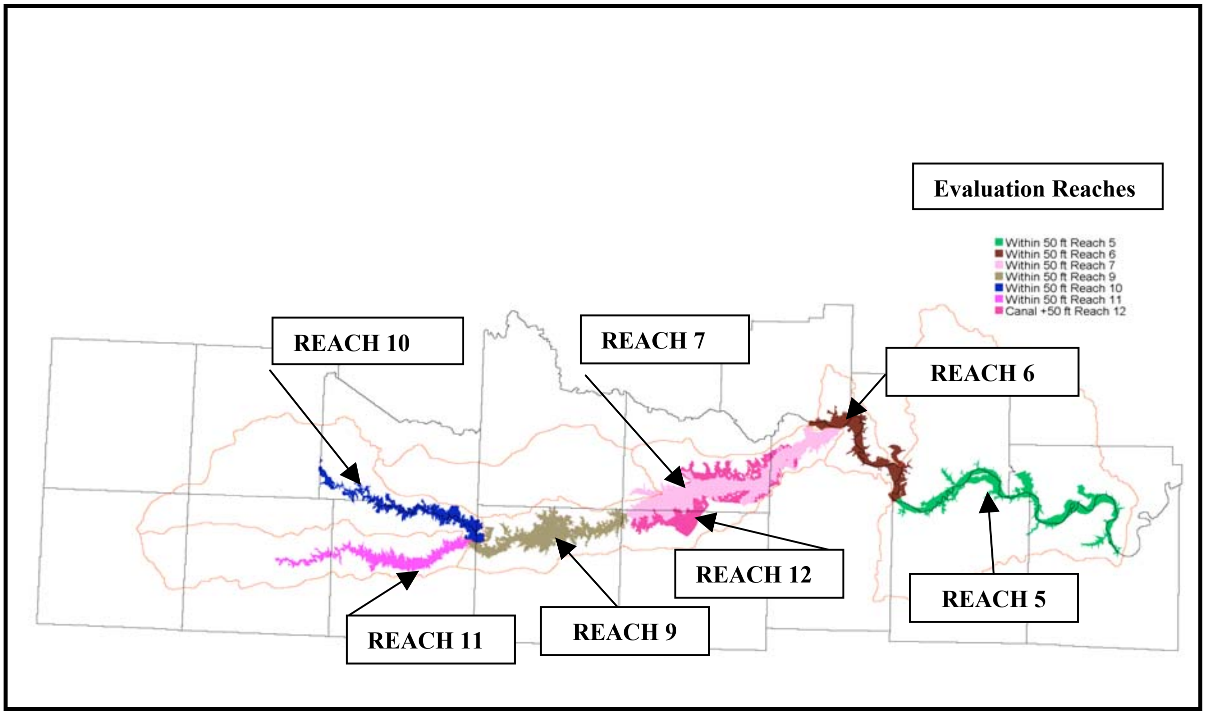
With the project, reduced chloride levels should increase crop yields and farmer net return relative to the No Action alternative. Benefits would be realized both by the conversion of dryland farming to irrigated farming and by increased yield as a result of decreased salinity. McCarl *et al.* (2000 and 2001) evaluated the benefits to agriculture over 50 years with benefits remaining constant over the remainder of the 100-year life of the proposed project. An agricultural evaluation update was completed in September 2001 by Texas A&M University in which Lake Kemp water availability was evaluated based on three scenarios:

- First, it was assumed that 71,500 acre feet was available 100% of the time.
- Second, 100,000 acre feet of water was available 89% of the time, and 50,000 acre feet was available 11% of the time.
- Third, 120,000 acre feet was available 82% of the time, 60,000 acre feet was available 16% of the time, and 30,000 acre feet was available 2% of the time.

In addition, two management scenarios were developed:

- One assumed that optimal land usage practices were in place as the existing condition as well as in the future to maximize net returns to the farmer.
- The second management scenario assumed that the existing land irrigation of about 15,000 acres is the current condition and would be optimized for maximum net returns, and that optimal land irrigation would occur in the future based on optimizing net returns.

FIGURE 4-1
STUDY AREA ECONOMIC REACHES



Agricultural benefits would be confined to reaches currently served by the Wichita County Water Improvement District No. 2 and downstream (Economic Reaches 5, 6, 7, 9, 10, 11, and 12 as shown in Figure 4-1). In addition, agricultural benefits would be anticipated to occur within 50 elevation feet above the affected stream, since irrigation is dependent upon availability of improved water. For study purposes, it was assumed that all the water available for irrigation on the Red River/Wichita River confluence downstream to Lake Texoma would be utilized in the optimal irrigation solution regardless of project implementation.

For economic reaches 7 and 12 (hydrologic reach 8), irrigation water use is approximately 45,000 acre feet currently, decreasing to approximately 32,000 acre-feet by 2055 with the No Action alternative. With the proposed plan, water use for irrigation ranges from 119,000 acre-feet in 2005 to 120,000 acre-feet by year 2055. These changes in irrigation were also used in predicting economic benefits. According to McCarl *et al.* (2001), the principal increase in irrigated acres with the project is projected to occur primarily in cultivation of alfalfa, bermuda, and tomatoes. The results of the study indicated that increased water supplies would also increase benefits to agriculture. Average annual benefits were found to range from $1.98 to $4.511 million depending on the scenario and management practice used (McCarl 2001, Plan 5). The report is available at http://www.swt.usace.army.mil/LIBRARY/Library.CFM.

g. Cultural Resources. In accordance with the provisions of the National Historic Preservation Act and 36 CFR 800, the USACE has consulted with the Texas Historic Preservation Office, interested Native American tribes, and the interested public regarding the potential impacts the proposed project may have on cultural resources. Further identification, evaluation, and treatment of cultural resources that may be affected by the project would take place in accordance with 36 CFR 800 once the USACE has access to the project area.

1. Area VII Collection Area, Spray Field, Pipeline and Power Corridors. A total of six prehistoric sites dating to the Archaic period were found within the vicinity of Area VII during a preliminary cultural resource reconnaissance survey (Hughes 1972). In addition, a cultural resources inventory of a portion of the proposed Area VII pipeline route was performed in 2001 (Schreyer *et al.* 2001). This inventory resulted in the identification of 11 prehistoric archeological sites and 1 historic farmstead. In consultation with the Texas State Historic Preservation Office, all of the sites recorded in the 2001 inventory have been determined to be ineligible for listing on the National Register of Historic Places.

Once final locations and alignments are determined for the Area VII power corridor and spray field, these areas would be surveyed for cultural resources, as would that portion of the Area VII pipeline corridor that was not previously surveyed in 2001. Any cultural resources identified that may be affected by the proposed project would be evaluated and treated in accordance with 36 CFR 800.

2. Area VIII Spray Field. The exact location for this spray field has not been identified. Once the location is known, and prior to construction, the area would be inventoried for cultural resources. If any cultural resources are discovered in this area, they would be evaluated and the potential impacts of the project assessed in accordance with 36 CFR 800.

3. Area X Collection Area, Spray Field, Pipeline, and Power Corridors. Late in 1994, the proposed pipeline corridor connecting the Area X collection area and Truscott Brine Disposal Reservoir was inventoried for cultural resources, and two sites were identified within the corridor (Largent *et al.*, 1995). Cultural resources identified by Largent *et al.* (1995) would be evaluated in consultation with the Texas State Historic Preservation Officer and interested Native American tribes. All cultural resources affected by construction of the Area X pipeline would be evaluated and treated in the same manner as described above. Any potential realignments of the pipeline corridor and yet to be identified location of the spray field and power corridor at Area X would require new cultural resource surveys. Any cultural resources identified in these surveys that may be affected by the project would be evaluated and impacts assessed in accordance with 36 CFR 800.

h. Land Use Changes. As discussed in previous sections, land use changes are occurring in the Wichita River Basin without project implementation. These changes are largely the result of Senate Bill 1 which provided funding for brush management under the State's Drought Contingency Plan. The goal of this program is conversion of brushland to native grasses.

1. Land Use at Area VII. The proposed Area VII collection and disposal system is located in the northwestern region of Texas as shown in Figure 1-1. The proposed project begins with the collection and evaporation spray fields at Area VII on the North Wichita River 11 miles northwest of Truscott, Texas. Collected brine from Area VII would be transported via pipeline southeasterly to a second spray field and outfall at Truscott Brine Disposal Reservoir. The proposed Area VII system would occupy portions of Cottle, Foard, and Knox counties. The collection facility, spray fields and pipeline would occupy native short-grass prairie rangelands and some croplands. The topography of the land crossed by the pipeline ranges from gently sloping to rough breaks with several stream crossings.

The collection facility would consist of a low-water dam and pipeline intake structure. Approximately 72 acres of land would be converted for construction of these features. In addition, approximately 48 acres of land would be required for construction and operation of the Area VII spray field. The spray field would be located adjacent to the Area VII collection facility. Access to the collection and associated evaporation area would be on an existing roadway. Thus, access would not result in land use changes.

The brine transport pipeline would traverse southeast of the Area VII collection area to Truscott Brine Disposal Reservoir. Approximately 181 acres of mixed rangeland and cropland would be needed for the pipeline right-of-way and maintenance road. The maintenance road would be located within of the pipeline easement. The easement would be 100-feet wide from approximately 15 miles from the collection area to the outfall, though not all of the 100-foot easement would result in land use changes.

Once brine from Area VII has been pumped to the Truscott Brine Disposal Reservoir, it would pass through a second evaporation spray field. The area of this spray field, used for both Area VII and Area X brines, has been estimated at 28 acres and would convert existing mesquite-juniper uplands to spray field and outfall facilities. Carryout from the spray field has been estimated, based on the existing Area VIII spray field, to impact an additional 28 acres.

Temporary land use changes would also result from construction of Area VII facilities. These areas would be associated with the collection facility and borrow site. At the borrow site, which has yet to be located, the Government would excavate and remove soil, dirt, and other materials from the land. The land would then be allowed to return to its original use.

2. <u>Land Use at Area VIII</u>. Area VIII is located in the northwestern region of Texas, as shown in Figure 1-1. The two spray fields associated with Area VIII would be located at the intake and outfall of the existing Area VIII brine pipeline. The outfall spray field has already been constructed and is currently in operation. The pipeline would originate on the South Wichita River and transport brine approximately 12 miles in a northeasterly direction to Truscott Brine Disposal Reservoir. The proposed Area VIII intake point spray field would be located in King County. The proposed structures would occupy native short-grass prairie rangeland and some cropland.

The collection, pumping, and pipeline facilities for Area VIII have been previously constructed and would not result in additional land use changes. Construction of a spray field at the intake of the Area VIII pipeline would require approximately 37 acres of land. This spray field would be located adjacent to the Area VIII collection facility and would convert existing rangeland to evaporation fields. Carryout from the spray field, as estimated based upon the existing Area VIII spray field, would require an additional 37 acres of land.

3. <u>Land Use at Area X</u>. Area X is located in the northwestern part of Texas as shown in Figure 1-1, approximately 6 miles west of Truscott (Knox County) and 13 miles northeast of Guthrie (King County). Western Knox County and King County are predominately rangeland. Collection facilities at Area X have been previously constructed. The proposed plan would add a spray field at the pipeline intake as well as a pipeline from the collection area to the Truscott Brine Disposal Reservoir. The proposed spray field area and pipeline alignment would occupy native short-grass prairie rangelands. The topography of the land crossed by the pipeline ranges from gently sloping to rough breaks.

The spray field at Area X would occupy approximately 32 acres located some 250 feet southeast of the existing Area X collection facility. Overspray would affect approximately 32 additional downwind acres. The spray field would convert land use from rangeland to evaporation fields. Construction of the pipeline from Area X to the Truscott Brine Disposal Reservoir would require approximately 146 acres for the pipeline and maintenance road. The service road would be located on top of the pipeline easement. The pipeline alignment would generally traverse east of the collection area to the Truscott Brine Disposal Reservoir with a few short bends to the north and south. The pipeline/road easement would be 100 feet wide for the approximately 10 miles from the collection area to Truscott Brine Disposal Reservoir, though not all of the 100-foot easement would result in land use changes. Land use along the pipeline alignment would be converted from rangeland and cropland to pipeline easement or gravel maintenance road.

4. Land Use at Truscott Reservoir. At the Truscott Brine Disposal Reservoir, the dam could potentially be raised 2.4 feet. This would be accomplished by installing a reinforced concrete stem wall atop the existing dam. Raising the level in the lake would change the existing top of dam elevation from 1512.5 to 1514.9. The Truscott spillway crest would be elevated from 1502.0 to1505.3. Raising the top of dam elevation would result in an overall expansion of Truscott Brine Disposal Reservoir from 2,980 acres to 3,700 surface acres, converting existing mesquite-cedar uplands to aquatic brine habitat. Implementation of this phase of the project is not anticipated to occur for roughly 75 years, during which the USACE would monitor lake filling. Improvements to the spray field configuration may also be realized during this time period that would make future dam construction unnecessary.

5. Environmental End Use by Reach: With the project operational and with improved water quality, there would be an increase in agricultural production and a noticeable shift in crop yields and cropping patterns on irrigable lands along the Wichita River and a portion of the Red River. As determined from the Texas A&M studies (2000), most of the agricultural changes are expected to occur from the conversion of dryland farming of Bermuda grass/hay to irrigated farming of alfalfa.

Under existing conditions, there are 15,000 acres of irrigated land. With implementation of the Proposed Plan, there would be an increase to 58,202 acres of irrigated land. Of this amount, approximately 43,200 acres would be transformed or converted to irrigated lands. Approximately 42 acres of pasture, 3,011 acres of idle farmland, and 40,128 of dry farmland would be converted to irrigated farmland with the project.

While the number of irrigated acres would increase, the conversion would come from other types of agricultural lands. Most of the irrigation would occur in economic reaches 5 and 7. Minor amounts are projected to occur in economic reaches 6 and 12.

i. Wichita River.

1. Stream Water Quality. Within the Wichita River Basin TDS rarely exceeds 50,000 mg/l (Lewis and Dalquest 1957). With the proposed project, TDS in Reach 10 would decrease by 71% (to approximately 3,285 mg/l), at least 50% of the time. Chlorides would decrease by 75% (to approximately 1,197 mg/l) at least 50% of the time. These estimates assume operation of both Areas VII and X on the North and Middle Forks of the Wichita River.

With the proposed project, TDS in Reach 11 would decrease by 52% (to approximately 7,625 mg/l), at least 50% of the time with the Area VIII collection facility in operation assuming no brush management. Similarly, chloride concentrations would decrease by 62% (to approximately 2,790 mg/l) at least 50% of the time with Area VIII in operation on the South Fork of the Wichita River.

The proposed plan would reduce sediment loading to the Wichita River downstream of the brine collection areas (USACE 1980, 1976). Control facilities at Areas VIII and X alone were estimated to reduce the amount of alluvial material presently being deposited in Lake Kemp by roughly 10% (WTSU 1972).

In addition to removal of dissolved salts and sediment in the Wichita River, changes in water quality related to increased irrigation return flows could occur in Reach 8 as a result of the proposed project. Reaches potentially most impacted by these changes would be those where greatest magnitudes of return flows are expected. These potential changes could include periodic increases in nutrients, pesticides, certain metals, and other constituents. The potential for release of these chemicals to the stream would depend on the amount of irrigation that develops and the methods employed for irrigation in the future as water demands increase.

With the proposed plan, the estimated mean discharge of nitrogen concentrations could increase from 1.42 mg/l to 10.88 mg/l in the Wichita River at the Charlie Gage (Walker 2001). Similarly, phosphorous concentrations were projected to increase from 0.42 mg/l to 1.64 mg/l (Walker 2001). This increase in nutrient levels could potentially impact algal production in receiving waters and increase the potential for dissolved oxygen variability (USACE 2001d). In addition, Reach 8 and downstream would potentially receive higher concentrations of pesticides and lower concentrations of herbicides (due to decreased need in irrigated agriculture) (USACE 2001d). To address these concerns, a stream water quality monitoring plan has been established for the Wichita River Basin. Details of this plan are included in the EOP (Appendix A).

2. Selenium. Since the discovery of deformities and reduced reproductive capacity of aquatic birds in the San Joaquin Valley, California, during the mid-1980s, national attention has focused on implications of elevated Se concentrations in aquatic systems. Selenium was identified as the primary cause of the disappearance of fish species, the decrease in aquatic bird hatching success, and the high (64%) rate of deformed and dead bird embryos at Kesterson National Wildlife Refuge (KNWR) within the San Joaquin Valley (USFWS 1992). These findings have generated a considerable amount of Se-related research and prompted increased awareness of Se issues in water resources planning throughout the western United States.

Selenium is an essential trace element that occurs naturally in the environment. It is widely distributed in rocks, soils, water, and living organisms. In the western United States, it is most common in marine sedimentary deposits. Selenium is highly mobile and biologically available in arid regions having alkaline soils, typical of the project area. The mineral is problematic in water resources because elevated levels of Se have been shown to cause reproductive failure and deformities in fish and aquatic birds.

Issues related to potential Se-related impacts associated with the proposed project have been the topic of considerable scoping discussion among the USACE and resource agencies. In response to these concerns, the USACE has conducted several studies and prepared detailed documents addressing these issues. These include a Se evaluation originally prepared for the entire RRCCP (USACE 1993a), an evaluation of the potential for Se-related impacts associated with various alternatives for chloride control in the Wichita River Basin (USACE 2000a), and results of intensive monitoring activities during 1997-1998 at Truscott Brine Disposal Reservoir and brine collection facilities in the Wichita River Basin (USACE 2001c). These reports are incorporated by reference and can be found at http://www.swt.usace.army.mil/LIBRARY/Library.CFM. As Se-related issues for the project are complex and require considerable explanation, these documents should be reviewed for a complete understanding of this topic. Selenium-related issues with respect to brine collection facilities and potential impacts on the Upper Wichita River system are discussed in this section.

Elevated concentrations of Se occur naturally in some streams of the Wichita River Basin. While surface waters typically contain less than 0.2 µg/l (parts-per-billion) total Se (Skorupa *et al.* 1996), average concentrations of 3.0, 9.2, and 11.4 µg/l have been measured at Areas VIII, VII, and X, respectively (USACE 2000a). Owing to these concentrations, the North Fork of the Wichita River is currently listed on the State of Texas 303(d) list as Se-impaired by the TNRCC.

Collection facilities associated with the proposed project are designed for regular outflow of collected brines via pumping to disposal areas. These systems would also undergo frequent flushing events during seasonal periods of high flow. The result of this design is a greatly reduced capacity for long-term increases in chemical constituents at these collection facilities. Brine pumping during collection periods would serve to continually remove Se mass from these areas. In addition, deflation of collection facility weirs during seasonal high flow periods would result in regular river flows through collection areas. Accordingly, no long-term increases in Se are anticipated in these areas.

Operation of brine collection facilities would reduce Se loading to downstream reaches due to Se removal and transport to Truscott Brine Disposal Reservoir. Because naturally-occurring waterborne Se concentrations at some collection areas generally exceed levels reported as hazardous to fish and wildlife, positive impacts to downstream biota could be realized.

Significantly reduced Se concentrations in fish below Area VIII were measured during monitoring efforts in 1997 and 1998 (USACE 2001c) indicating that mass removal may be providing some downstream Se-related benefits at this location. Overall, the net effect of brine collection facility operations could be substantially reduced Se loading to downstream reaches of the Wichita River and Upper Red River Basin with potential positive impacts to fish and wildlife in these areas. The TNRCC expressed a similar opinion in a letter dated July 8, 1996, to the RRA.

Adverse Se-related impacts associated with brine collection facilities could conceivably occur if:

1) operation of these facilities resulted in an increase in Se concentrations in environmental media to levels toxic to biota and/or
2) construction of these facilities created an "attractive nuisance" encouraging increased use by breeding birds and exposing them to elevated Se levels.

At Area VIII, data collected during 1997-1998 monitoring (USACE 2001c) did not indicate such impacts at this facility. Site-specific evaluation for each collection facility would need to be conducted to address these concerns upon project implementation. Environmental monitoring for Se-related impacts at collection facilities is, therefore, included in the USACE's proposed Se monitoring plan (EOP, Appendix A).

3. Flow. Resource agencies have expressed concerns about the impact of the proposed project with respect to naturally occurring low flows on the Wichita River. The main concern was the impact of increased low flow periods on indigenous salt tolerant species. Table 4-2 lists the number of zero flow days under natural conditions and the proposed plan. Note that only Areas VII and X affect Reach 10. Area VIII was included for comparison. Table 4-2 also lists the low flow days during the period of record at each gage. Table 4-3 presents the same information in terms of overall percent. The number of days shown in Table 4-2 refers to the number of days during the period of record for that reach. The period of record spanned not one year, but decades. The number of days reflects not all calendar days during the period of record but only the days during which flow gages on each reach were recording.

TABLE 4-2
UPPER WICHITA RIVER: LOW FLOW DAYS

Location[1]	Plan	Average Flow Rate (cfs)	No. of Days ≤ 0 cfs	No. of Days ≤ 1 cfs
Reach 11[2]	No Action alternative	42.9	1195	1821
	Proposed Plan	42.5	1230	2055
Reach 10[2]	No Action alternative	66.9	2	201
	Proposed Plan	62.2	1131	1350
Reach 9*[3]	No Action alternative	228.2	109	181
	Proposed Plan	227.6	114	202

*Seymour gage data was multiplied by a factor of 1.42 to simulate inflows into Lake Kemp. Seymour gage data was available for 12/59 – 7/79
[1] Figure 3-1
[2]Period of Record 10/61 – 9/98, 13,505 days
[3]Period of Record 12/59 – 9/79, 7,604 days
Source: USACE 2001a

TABLE 4-3
UPPER WICHITA RIVER: PERCENTAGE OF ZERO-FLOW DAYS

	Reach 9** Flow ≤ 0	Reach 10* Flow ≤ 0	Reach 11* Flow ≤ 0
No Action alternative	1.4	0.0	8.8
Proposed Plan	1.5	8.4	9.1

*Period of Record 10/61 – 9/98, 13,505 days
**Period of Record 12/59 – 9/79, 7,604 days
Source: USACE 2001a

Within the Upper Wichita River, zero flow days would increase slightly (0.1%) in Reach 9 without brush management. Reach 11, which is associated with Area VIII, would not be affected by the proposed plan because Area VIII is currently in operation. As shown in Table 4-3, an increase in zero flow days of 0.3% is estimated to have occurred since start-up at Area VIII. In Reach 10, the percentage of zero flow days would increase from 0% under natural conditions to 8.4% under the proposed plan without brush management. The effects of brush management are discussed later in this section.

This increase in zero flow days is of concern to resource agencies due to potential reductions in refugia pools. However, the continuing presence of refugia pools and brine-adaptive species in Reach 11 under natural conditions indicates that this should be a limited condition. Under natural conditions, the zero flow days in Reach 11 (8.8%) is greater than would be seen in Reach 10 under the proposed plan (8.4%). In the Lower Wichita River, below Lake Kemp, a review of the period of record for Reach 8 indicated that there have been no zero low flow days under natural conditions.

Flow duration data, other than zero flow conditions, was determined for the No Action alternative and the proposed plan. The differences in flow between the No Action alternative and proposed project conditions are very minor as shown in Table 4-4.

TABLE 4-4
UPPER WICHITA RIVER FLOW DURATION RESULTS

Reach[1]	Plan	Flow Duration (cfs) Percent of Time Equaled or Exceeded 1	5	10	20	50	80	90	95	99
Reach 11[2]	No Action	820.3	116.2	49.1	21.0	7.6	2.2	0.3	0.0	0.0
	Proposed Plan	820.0	116.0	49.0	20.9	7.2	1.8	0.2	0.0	0.0
Reach 10[2]	No Action	1,030.0	143.0	67.0	38.0	20.0	11.0	7.5	4.8	0.7
	Proposed Plan	1,029.1	140.6	65.6	37.6	18.7	7.3	1.0	0.0	0.0
Reach 9[3]	No Action	4,004.4	815.1	313.8	125.0	42.6	18.5	9.1	3.5	0.0
	Proposed Plan	4,002.8	814.3	313.4	124.6	42.3	17.0	8.1	2.9	0.0

[1] Figure 3-1
[2]Period of Record 10/61 – 9/98, 13,505 days
[3]Period of Record 12/59 – 9/79, 7,604 days
Source: USACE 2001a

Currently, the Texas State Soil and Water Conservation Board (TSSWCB) and the RRA have proposed to implement a brush management program in the basin upstream from Lake Kemp. It is estimated that a brush management program could increase the net watershed yield between 27.6% (32,900 acre-feet) and 38.9% (46,330 acre-feet) in the defined control areas (USACE 2001a). In this portion of the basin, flows in the rivers with brush management would likely be restored to near pre-settlement conditions and would benefit the aquatic community as a whole.

As a result of the TSSWCB/RRA brush management program, the base (future without-project) conditions have been adjusted to reflect these additional activities within the basin. Brush management activities within the basin are separate from the proposed action being evaluated in this document and are projected to occur with or without the USACE chloride control project as provided for in Senate Bill 1. Table 4-5 illustrates the impact of brush management (50% implementation) on the number of zero flow days experienced in hydrologic reaches 9, 10, and 11. Evaluation of hydrology with brush management and the proposed project (Table 4-5) indicates that the proposed project would not increase the number of zero flow days over current conditions in Reach 11 and would increase the zero flow days in Reach 9 by 0.1% over the period of record.

In comparison, the project would increase the number of zero flow days in Reach 10 by 3.3 – 4.5% over current conditions. The number of zero flow day in Reach 10 would increase over current conditions but would be half or less that currently seen in Reach 11 under current conditions. Brush management would also lessen impacts of the proposed project on Reach 10 zero flow days by approximately one-half.

TABLE 4-5
ZERO FLOW DAYS EXPERIENCED IN UPPER WICHITA RIVER BASIN

Reach	Natural Conditions without brush management*	Proposed Plan without brush management	Proposed Plan with brush management - 27.6% yield increase	Proposed Plan with brush management - 38.9% yield increase
9[1]	109 (1.4 %)	114 (1.5 %)	113 (1.5 %)	112 (1.5%)
10[2]	2 (0.0 %)	1131 (8.4 %)	614 (4.5 %)	440 (3.3%)
11[2]	1,195 (8.8 %)	1,230 (9.1 %)	1,110 (8.2 %)	1,091 (8.1 %)

*No difference was identified across the range of predicted watershed yield under the without-project conditions with brush management.
[1] Period of Record 12/59 – 9/79. 7604 days
[2] Period of Record 10/61 – 9/98, 13505 days
Source: USACE 2001a

Water enters the lower Wichita River primarily from surface runoff in times of precipitation and flood releases from Lake Diversion. During flood events, the brine collection dams would be deflated allowing all flood flows to pass downstream and eventually into Lake Kemp/Diversion. Downstream of Lake Diversion, flows are initially the result of discharge from the Dundee Fish Hatchery and, occasionally, flood releases. Flows from the Wichita Falls wastewater treatment plant enter the Wichita River further downstream. Irrigation return flows enter the steam from roughly 3 miles downstream of Lake Diversion to 4 miles east of Wichita Falls (personal communication, Jimmy Banks, WCWID No.2, 2002).

The potential for flow changes in the lower Wichita River was evaluated for increased irrigation and increased irrigation return flows. For areas below Lake Kemp (Reach 8) the primary source of flow change would be irrigation and excess irrigation runoff, or return flow. In addition, the potential also exists for increased municipal and industrial use of waters from Lake Kemp/Diversion. These flows would eventually be returned to the river, though reduced from their original volumes. Return flows from municipal and industrial use are typically 70-80% of water withdrawal. In the Lower Wichita River, below Lake Kemp, a review for Reach 8 indicated that implementation of the proposed plan would result in flow changes that are very minor.

4. Upper Wichita River Fish Communities. Echelle *et al.* (1995) described two major components of the fish assemblage present in the Wichita River upstream of Lake Kemp. The first of these components was comprised of fish species that were tolerant of a wide range of environmental conditions and were found to be widespread in their distribution inhabiting headwater and main stem reaches. The second component of the fish assemblages was comprised of fish species restricted to main stem reaches only. The three most common species in this category are all cyprinid species and include the Red River shiner, plains minnow, and speckled chub.

The aquatic community in the Wichita River including the North and Middle (Reach 10) and South (Reach 11) Forks of the Wichita River has the potential to be affected by the proposed project. These effects could include isolation of fish populations, and reduction in low flows and salinity levels in the streams downstream from the inflatable dams. These effects are discussed in the following subsections.

(a) Isolation of Fish Populations. In areas upstream of the chloride collection facilities in operation, the structure of the fish community is relatively simple comprised primarily of Red River pupfish, plains killifish, and mosquitofish. The Red River pupfish and plains killifish can tolerate high salinity levels and may be found in water with salinity greater than 100,000 mg/l, which is roughly three times the concentration of seawater (Echelle *et al.* 1972). However, salinity concentrations in the Wichita River Basin rarely exceed 50,000 mg/l (Lewis and Dalquest 1957). Both species prefer to live and spawn in shallow, relatively calm pool conditions. Pupfish have a long spawning period that extends from February to November (Minckley 1979), while killifish spawn May though July (Cross and Collins 1975). Both species can spawn at very high temperatures (greater than 80°F). Echelle *et al.* (1972) found that, although Red River pupfish are present in low relative abundance within waters with low salinity, they are only highly abundant in waters with salinity greater than 10,000 mg/l, where few other species are present. Conversely plains killifish can successfully compete in freshwater environments with a wide range of salinities.

The populations of the upper Wichita River basin have been genetically isolated since the early 1920's, when Lake Kemp and Lake Diversion, were constructed. Since that time it is unlikely that fish, particularly pupfish, have moved from fish Reaches 7 and 9, to Reaches 10 and 11. The pupfish community above Lake Kemp has been isolated genetically from the Red River populations since the 1920's.

(b) Flow Alterations. As shown in Table 4-5, when the combined effects of the brush management program and the proposed project are considered, it would be expected that there would be little flow-related effect (adverse or beneficial) on fish communities in fish Reaches 9 and 11.

Within Reach 10, reduced flows expected as a result of the project should not affect medium and high stream flow, thus the greatest potential for adverse impacts of flow reduction on fish species in the river would be isolation during extreme low flow or zero flow periods. It is important to note that collections in 1998 (Gelwick *et al.* 2000) were made at the height of summer (August 1998) and could be interpreted as a "worst case scenario" relative to low/zero flow conditions. Additionally, severe drought conditions were experienced during the summer of 1998, which further strengthens this "worst case scenario" and could partially explain the weak correlation between spatial differences in environmental conditions to differences in fish distribution. The predicted low/zero flows in Reach 10 could affect fish communities in a number of ways. Species dependent upon flowing water for reproduction, such as speckled chub (Cross *et al.* 1985) and possibly the plains minnow (Taylor and Miller 1990) and the Red River shiner (Gilbert 1980), may be negatively affected by low/zero flow days. In comparison, species able to survive and reproduce in harsh, restricted pool conditions, like the red shiner, mosquitofish, and fathead minnow, may compete successfully given a reduction of stream flows. However, for reduced flows to be detrimental to reproduction, they must correspond with a species spawning period. Smaller, less numerous refugia pools would concentrate fish, increasing competition for resources, magnifying predation among species, and increasing vulnerability to outside predators and commercial minnow harvesters. In addition, concerns expressed by resource agencies relating to flow reductions decreasing refugia pool depths, increasing water temperature, and decreasing dissolved oxygen may have been overstated. Physical and chemical characteristics of refugia pools (Table 4-6) located throughout the basin in August 1998 indicate that salinity concentrations rarely exceeded 10,000 mg/l, pools were well oxygenated relative to their location in the basin, and pool characteristics (percent canopy cover, dissolved oxygen, water temperature, etc.) were quite diverse among pools within a given stream reach (Gelwick *et al.* 2000).

TABLE 4-6
PHYSICAL/CHEMICAL CHARACTERISTICS OF WICHITA RIVER REFUGIA POOLS

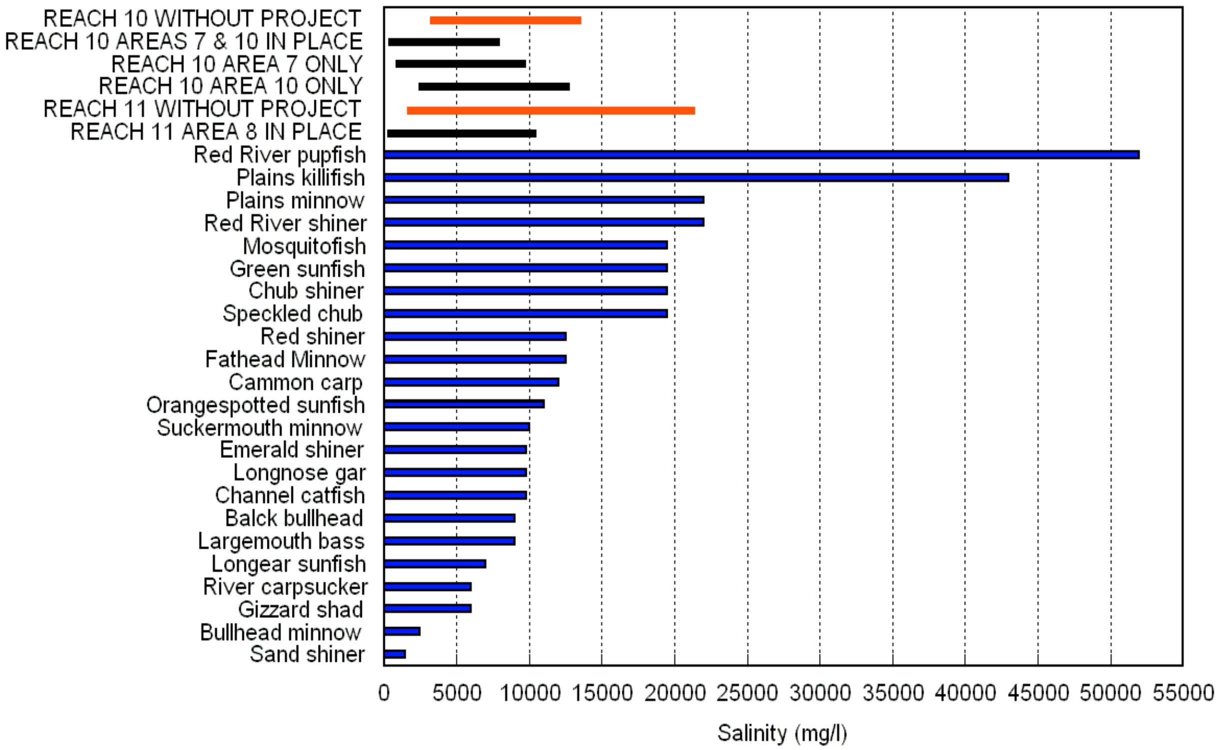
STREAM REACH	PERCENT REACH EVALUATED	POOL WIDTH (m)			POOL DEPTH (m)			WATER TEMPERATURE (^{O}C)		
		min	max	mean	min	max	mean	min	max	mean
5 & 6	0.84	0.5	75.0	8.5	1.0	7.0	3.8	23.0	35.0	29.3
9	0.49	1.0	30.0	4.7	1.0	7.0	4.2	26.0	33.0	29.0
10	0.26	3.0	30.0	4.1	2.0	7.0	4.1	25.0	31.0	27.8
11	0.03	5.5	30.0	4.0	2.0	7.0	4.0	25.0	32.0	29.0

STREAM REACH	DISSOLVED OXYGEN (mg/l)			CONDUCTIVITY (µS/cm)			TDS (mg/l)			SALINITY (mg/l)		
	min	max	mean	min	max	mean	min	max	mean	min	max	Mean
5 & 6	0.9	13	7.3	17	26740	2352	3.6	1261	288	3	12606	940
9	5.7	7.3	6.6	1576	14460	7145	316	1598	342	745	6099	3100
10	3.2	10.8	8.1	39	24390	8634	8.0	1556	867	18	10679	3834
11	4.1	9.8	7.7	39	1694	592	8.3	304	107	21	829	291

Source: Gelwick *et al.* 2000

(c) Salinity Reductions. Many rivers within the Upper Red River Basin are subject to very high salinity levels, occasionally exceeding 100,000 mg/l (Echelle *et al.* 1972; Lewis and Dalquest 1957). Within the Wichita River Basin salinity ranges from 2,000-21,000 mg/l in Reach 11 and from roughly 3,500-13,500 mg/l in Reach 10 as shown in Figure 4-3. Salinity tolerances for fishes in the Wichita River Basin as well as projected salinity ranges for Reaches 10 and 11 under the proposed project and No Action alternatives, assuming no brush management, are shown in Figure 4-2. Salinity ranges were calculated by multiplying 1.648 by the chloride loading estimates from concentration duration tables formulated by the USACE. This estimate assumes that all salinity is derived from sodium chloride; therefore, calculated salinity values may be somewhat less than actual salinity levels.

FIGURE 4-2
WICHITA RIVER FISH SALINITY TOLERANCES (Modified from Echelle *et al.* 1972)



Ranges of salinity present in Reaches 10 and 11 under proposed project and No Action alternative conditions, with no brush management, are presented in Figure 4-2 (black and red bars). In Reach 10, salinity concentrations would decrease, at least 70% of the time; the decrease would range from 25% (Area X only) to 75% (Areas VII and X); and resulting concentration would be expected to be between 5,000 and 1,500 mg/l, respectively. With only Area VII, the expected decrease would be 62.5% and the resulting concentration would be expected to be approximately 2,470 mg/l. These estimates are based on concentration duration curves (USACE 2001a) for the period of record (October 1961 through September 1998). In Reach 11, with Area VIII in operation and no brush management, salinity concentrations would decrease, at least 70% of the time by about 64%, and the resulting concentration would be approximately 3,000 mg/l. As a result, species tolerant of salinity levels greater than 10,000 mg/l would likely decrease in relative abundance in habitats of decreased salinity due to an increase in relative abundance of less tolerant species. It is also expected that the brush management program with its increase in watershed yields could cause additional decreases in salinity concentrations in Reaches 10 and 11, which would cause additional impacts on the salt tolerant fish community.

In these reaches (10 and 11), impacts to the salt tolerant community as a result of decreased salinity concentrations would probably not occur over long-term periods of time. Increases in less salt tolerant species in these areas would most likely be limited to short-term pulses resulting from above average rainfall events and associated flow increases. As base flow rates returned, environmental conditions (salinity concentrations) would become less favorable for the less salt tolerant species. Evidence of a similar pulse of less salt tolerant fishes into Oscar Creek (Jefferson County, Oklahoma) has been observed (Pezold and Clyde, unpublished data). Oscar Creek is generally considered to be the easternmost extent of the Red River pupfish. The fish community in Oscar Creek is very similar to the salt tolerant communities of the Wichita River Basin and is primarily comprised of Red River pupfish, plains killifish, and mosquitofish. Field Observations and collections made in May 1994 (Table 4-7) indicates that fish species more commonly found in less salt tolerant communities can and do move into Oscar Creek for brief periods, as a function of temporal conductivity variations. Subsequent field collections in May 1996 and May 1997 (Table 4-7) indicate that these movements of less tolerant fish species into Oscar Creek occur infrequently and impacts to the salt tolerant community appear to be minimal. Similar patterns would be expected in the upper Wichita River Basin.

TABLE 4-7
SPECIES COMPOSITION AND RELATIVE ABUNDANCE OF FISH
OSCAR CREEK, JEFFERSON COUNTY, OKLAHOMA

Scientific Name	Common Name	5/31/94+1 N=1206*	5/29/962 N=249	5/23/973 N=76
Ameiurus melas	Black bullhead	0.08		
Ameiurus natalis	Yellow bullhead	0.08		
Cyprinella lutrensis	Red shiner	48.92		52.63
Cyprinodon rubrofluviatilis	Red River pupfish	4.23	61.85	18.42
Dorosoma cepedianum	Gizzard shad	0.08		
Fundulus zebrinus	Plains killifish	34.58	38.15	17.10
Gambusia affinis	Mosquitofish	1.82	**	9.21
Lepomis cyanellus	Green sunfish	1.99		
Lepomis humilis	Orangespot sunfish	0.08		
Lepomis macrochirus	Bluegill sunfish	0.42		
Lepomis megalotis	Longear sunfish	1.82		
Micropterus salmoides	Largemouth bass	0.49		
Notemigonus chrysoleucas	Golden shiner	0.08		
Notropis stramineus (ludibundus)	Sand shiner	0.42		2.63
Pimephales notatus	Bluntnose minnow	0.16		
Pimephales vigilax	Bullhead minnow	4.23		
Pomoxis annularis	White crappie	0.49		
TOTAL		100.0	100.0	99.99

\+ Field notes indicate that less salt tolerance species were exhibiting signs of physiological stress.
* Sample Size
** Mosquitofish were not included in total counts but were present in the stream reaches analyzed here.
1 Specific conductance unknown, assumed to be freshwater pulse
2 Specific conductance: 5900 µS/cm
3 Specific conductance: 11,000 µS/cm
Source: Pezold and Clyde, unpublished data

(d) Summary of Upper Wichita Fish Community Impacts. Changes in the composition of fish communities in the Wichita River Basin have been predicted to occur as a result of proposed chloride control efforts at Areas VII, VIII, and X. It has been predicted that species such as the Red River pupfish and Red River shiner, which are adapted to high salinity waters, could decrease in numbers as a direct result of habitat modification and from secondary impacts caused by increased competition from less tolerant species. Within the Upper Red River basin (which includes the Wichita River Basin) as a whole, the University of Oklahoma (1975) suggested that populations of some fish species could experience a decrease. However, none of the existing species were predicted to be extirpated from the system and 24 species were predicted to have a positive response to decreased salinity. Fish communities outside of impacted reaches were not predicted to change significantly.

5. Lower Wichita River (Downstream from Lake Diversion). As discussed in Section 4(i)(3), stream flows in the Wichita River downstream from Lake Diversion result from local runoff during precipitation, flood releases from Lake Kemp/Lake Diversion, discharge from the Dundee Fish Hatchery and municipal wastewater and irrigation return flows. Implementation of the proposed project would have no effect on runoff, flood releases from Lake Kemp/Lake Diversion, or the discharge from the Dundee Fish Hatchery. However, implementation of the proposed project would result in greater use of Lake Kemp storage for irrigation and additional irrigation return flows. Thus, the proposed project would be expected to have no effect on the flow of the Wichita River downstream from Lake Diversion during the non-irrigation season and a minor beneficial effect on the river's flow during the irrigation season. A diverse fish community that includes salt tolerant and salt intolerant species exists in the reach of the Wichita River downstream from Lake Diversion. It would be expected that the predicted changes in water quantity and water quality attributable to the proposed project would have little effect on the fish community in the Wichita River downstream from Lake Diversion.

j. Truscott Brine Disposal Reservoir. Truscott Reservoir was designed as a brine disposal site, receiving collected brines from the chloride control collection sites. The reservoir is located on Bluff Creek, a south bank tributary of the North Fork of the Wichita River. The drainage area of the basin is 26.2 miles and extends approximately 6 miles northeastward to the dam site. The drainage area ranges in width from 7 miles at the upper end of the basin to approximately 3 miles at the dam site. The surrounding basin provides limited freshwater inflows and brine storage. Freshwater ponds have been constructed around the reservoir, providing freshwater fishing and stormwater capture. The economic design life of the reservoir is 100 years from the time of its filling in 1986, which coincides with initial operation of Area VIII. The reservoir was designed for total retention of collected brines and has no discharge. The primary potential impacts for the Truscott Brine Disposal Reservoir center around water quality, specifically chloride and Se levels, and reservoir volume. These issues are addressed in the following sections.

1. Chloride. Chloride concentrations in the reservoir have changed as the reservoir received brines from the operation of project components. In 1995, the chloride concentration of the reservoir was 18,000 mg/l (Echelle *et al.* 1995). Chloride concentrations in Truscott Reservoir would be expected to increase with continued operation and construction of the remaining authorized Wichita River components until an equilibrium is reached, which is predicted to be less than 100,000 mg/l. At this level, chloride concentrations in the reservoir would be greater than seawater (42,000 mg/l) and potentially suitable for a limited number of fish species. However, high chloride concentrations and their impacts are limited to the reservoir, itself, and are not anticipated to affect surrounding habitat.

2. Selenium Levels. Selenium is a naturally-occurring chemical element. It is a rather unusual element owing to a narrow difference between nutritionally essential and toxic concentrations (National Academy of Sciences 1971). Since the discovery of deformities and reduced reproductive capacity of aquatic birds in the San Joaquin Valley, California, during the mid-1980s, national attention has focused on implications of elevated Se concentrations in aquatic systems. These findings have generated a considerable amount of Se-related research and prompted recent reductions in recommended waterborne Se criteria, re-evaluation of agricultural drain water disposal practices, and increased awareness of Se issues in water resources planning throughout the western United States. Despite considerable research in this area, Se dynamics in

aquatic systems remain extremely complex, are often site-specific, and continue to be an area of considerable controversy in resource protection.

Brine that originates in some source streams of the Wichita River Basin contains elevated concentrations of selenium. At some source areas, naturally-occurring concentrations of Se exist at levels reported as hazardous to fish and wildlife and some streams in the study area have therefore been listed by the State of Texas as selenium "impaired". Removing brine from source streams not only removes chlorides, but also removes selenium, thereby reducing loads and potentially providing Se-related benefits to fish and wildlife downstream of collection areas. However, when brines are pumped to a brine disposal reservoir such as Truscott Brine Disposal Reservoir, concentrations in waters and sediments of these impoundments have the potential to increase over time, particularly when these reservoirs are operated as total retention (i.e., no outflow) systems. Primary environmental concerns associated with elevated concentrations of Se in aquatic environments are often impacts on reproduction and embryonic development of bird species using these areas as these impacts may be the first biological indication of Se contamination problems (Lemly and Smith 1987). Accordingly, evaluations have been conducted on potential impacts of brine disposal at Truscott Brine Disposal Reservoir and potential Se-related impacts on semi-aquatic nesting birds.

Issues related to potential Se-related impacts associated with the proposed project, and Truscott Brine Disposal Reservoir in particular, have been the topic of considerable discussion among the USACE and resource agencies. In response to these concerns, the USACE has conducted several studies and prepared detailed documents addressing these issues. These documents include a Se evaluation originally prepared for the entire RRCCP and proposed Crowell Brine Lake (USACE 1993a), an evaluation of the potential for Se-related impacts associated with various alternatives for chloride control in the Wichita River Basin with considerable discussion of potential impacts on Truscott Brine Disposal Reservoir (USACE 2000a), and results of intensive monitoring activities during 1997-1998 at Truscott Brine Disposal Reservoir and brine collection facilities in the Wichita River Basin (USACE 2001c). These reports are incorporated by reference and can be found at http://www.swt.usace.army.mil/LIBRARY/Library.CFM. As Se-related issues for the project are complex and require considerable explanation, these documents should be reviewed for a complete understanding of this topic. Selenium-related issues related to Truscott Brine Disposal Reservoir are summarized in this section.

When pumped to Truscott Brine Disposal Reservoir, concentrations of Se have the potential to increase in the reservoir over the life of the project. Factors making Truscott Brine Disposal Reservoir particularly susceptible to Se impacts are high evaporation rates coupled with a design for total retention of delivered brines and no capacity for outflow. The result is an inability of the system to reduce mass of delivered constituents (including Se) through outflow and periodic "flushing" during high flow events. Evaporation would tend to be the major process which could increase Se concentrations in reservoir waters. In contrast, other natural processes work to decrease Se concentrations in lake water. These processes include volatilization (transfer of Se-containing compounds from water and sediments to air) and adsorption to sediments. Both processes have been shown to significantly reduce waterborne Se in some systems (Cook and Bruland 1987, Thompson-Eagle and Frankenburger 1990, Bowie *et al.* 1996). While relative importance of these complex processes are unknown, it can be demonstrated that in excess of 87% of Se estimated to have been delivered to Truscott Brine Disposal Reservoir during a 14-year period following impoundment has been removed from the water column by these mechanisms (USACE 2000a). Based on studies of other lake systems, an estimated 5% of the Se is volatilized to the air. Risks of Se in the air are minimal to fish, wildlife and humans. The majority, estimated to be in excess of 82%, is adsorbed to sediments. The risks associated with Se in shallow sediments is greater than those for Se in buried sediments. As sediment continues to accumulate in Truscott Brine Reservoir, progressively more sediment is buried deeper, removing it from bioavailability and decreasing the risk associated with its presence.

As has been reported in other systems, it would appear that natural processes working to remove Se from the water column in Truscott Brine Disposal Reservoir are significant. Selenium is also measured in lake sediments as sediments accumulate Se and play an important role in Se cycling in some aquatic systems. At the reservoir, extensive monitoring conducted by the USACE (2001d) indicated that following approximately 11 years of project operation, selenium concentrations in samples of sediment were at or below "background" concentrations typical of these media in Se-normal environments. While in excess of 82% of the Se present has been estimated to have adsorbed to sediment, the mass of Se (parts per billion in water) compared to the entire mass of sediment present in the lake is extremely small. As a result, concentrations of Se in sediment are within the range for Se-normal environments. Continuing sediment monitoring would be performed at the reservoir as detailed in the EOP (Appendix A).

Birds are frequently among the most sensitive organisms to elevated Se in the environment (Lemly and Smith 1987). In particular, semi-aquatic nesting birds which are sedentary and feed in a localized area are most susceptible through feeding on prey (e.g., fish) which accumulate elevated Se levels from water and sediment. Transfer of Se from a bird to its eggs can result in decreased hatching rates and embryo deformities in areas with elevated Se (Skorupa and Ohlendorf 1991, Skorupa 1992). Bird species exhibit a wide range of tolerance to Se-related effects (Skorupa *et al.* 1996). Some species are particularly sensitive to Se while others can tolerate much higher concentrations. In general, bird species adapted to saline environments tend to have higher Se tolerances than those more adapted to freshwater systems (Skorupa *et al.* 1996). Birds take up Se quickly from the environment, but also lose accumulated Se rapidly (on the order of several weeks) when removed from an area of elevated Se (USFWS 1990). Certain fish species have also been shown to be very sensitive to Se with reproductive impacts observed in areas with elevated Se (Lemly 1996).

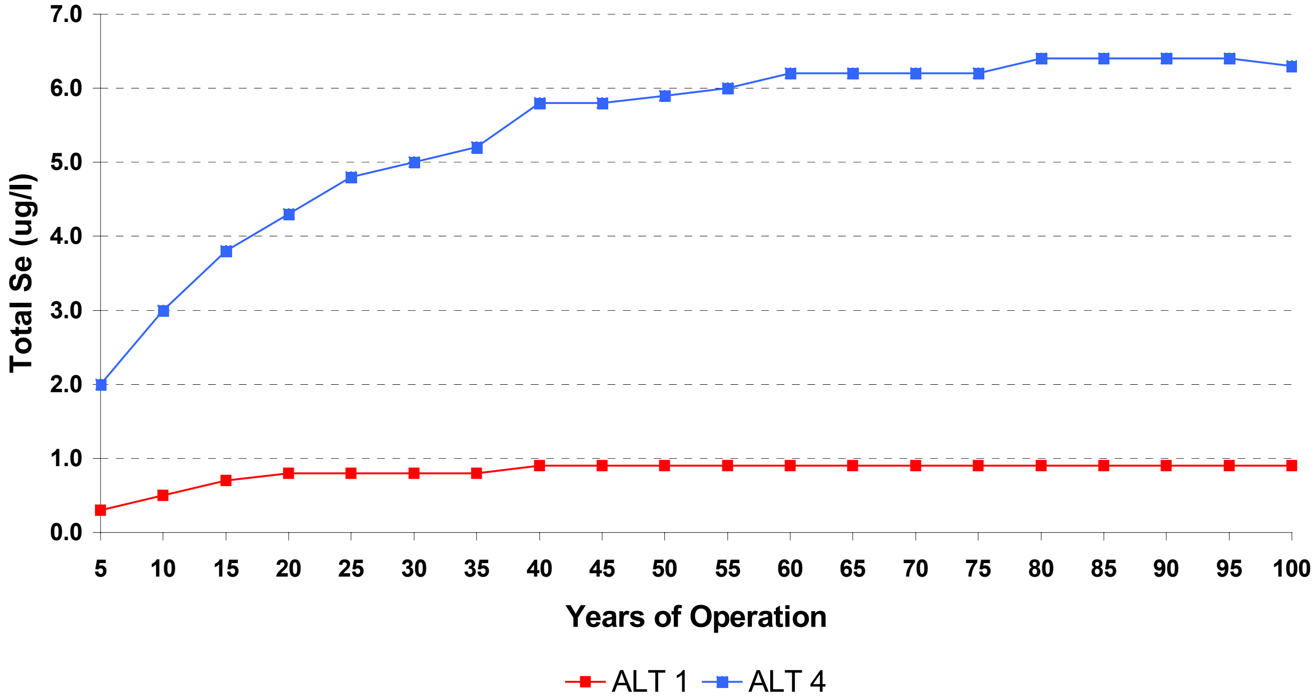
Processes that affect Se concentrations in aquatic systems and result in impacts on fish and wildlife are extremely complex and often depend on a wide variety of conditions unique to a particular system. For this reason, long-term predictions for a given system are very complex with a relatively high degree of uncertainty. Accordingly, site-specific Se impact analyses are often conducted based on a number of very conservative assumptions designed to be overprotective of the environment (i.e., overstate impacts) in an attempt to provide a "safety factor" for complexity and uncertainty. This degree of conservatism should always be recognized in interpretation of site-specific findings from these analyses. USACE's evaluations of potential Se-related impacts for Truscott Brine Disposal Reservoir have been conducted in this manner.

One area of apparent consensus among Se researchers is that waterborne Se concentration in and of itself is a poor predictor of impact on fish and wildlife and that water (as well as sediment) data should be evaluated along with Se concentrations in food chain organisms and fish and wildlife tissues for conclusions regarding Se impacts (Lemly 1996). For ultimate assessment of bird-related impacts, avian eggs are believed to be the best biotic matrix for risk/impact assessment though considerable between-species variability in embryo sensitivity exists (Lemly 1993, Skorupa *et al.* 1996). Complexities involved with using water-based criteria for impact prediction have even resulted in proposed methods for deriving site-specific water quality criteria for Se (e.g., Van Derveer and Canton 1997, Lemly 1998). Despite the complexities and uncertainties involved, it was still necessary to use predicted water and sediment Se concentrations in impact assessment for proposed additional brine pumping to Truscott Brine Disposal Reservoir.

The general approach applied to Se-related risk evaluation for this project was conservative estimation of water and sediment Se concentrations in Truscott Brine Disposal Reservoir and comparison of these values with concentrations reported in the scientific literature as protective of "fish and wildlife". Based on a review of current literature, this resulted in the use a concentration range of 2 to 10 μg/l (part per billion) as a minimum threshold value for impacts on breeding aquatic birds. As noted in "Alternatives for Chloride Control – Wichita River Basin and Truscott Brine Lake, Texas: Summarized Evaluation of the Potential for Selenium-Related Impacts of Wildlife" (USACE 2000a), the lower end of this range (2 μg/l) has been developed for protection of "fish and wildlife", is based on entire ecosystem protection, and is therefore not restricted to birds. A review of data supporting the lower end of the threshold range (as contained in Lemly 1993, 1995, 1996) indicates that some of the more sensitive species forming the basis for these recommendations are certain salmonid (e.g. trout and salmon) and centrarchid (sunfish) fish species. While this is certainly a rational approach for development of widely-applicable thresholds (as was the intention of these publications), application of resulting thresholds to a specific system (e.g., brine reservoir) and a restricted group of organisms (e.g., birds) yields uncertainty and may, in some instances, reflect protection of organisms that would never be expected to reside in a given environment (e.g., salmon, trout). As also noted in USACE documents related to this topic, threshold concentrations at the lower end of the range are dissolved concentrations (based on filtered water samples) while those used in USACE evaluations are based on total waterborne Se. Skorupa and Ohlendorf (1991) cited studies where correction factors of 1.85 to 1.98 were used in approximate conversions from dissolved to total recoverable Se. When these factors are considered and combined with a conservative modeling approach, use of the lower values in the minimum threshold range might be considered as "ultraconservative" for Truscott Brine Disposal Reservoir evaluations (as stated in USACE 2000a). The only value that could be found restricted exclusively to protection of breeding birds was the 10 μg/l threshold proposed by Skorupa and Ohlendorf (1991). It should also be noted that the current State of Texas water quality standard for Se is 5 μg/l. Professional judgment and an understanding of the basis for "threshold" concentrations were all considered by the USACE in Se-related impact assessment for Truscott Brine Disposal Reservoir evaluations.

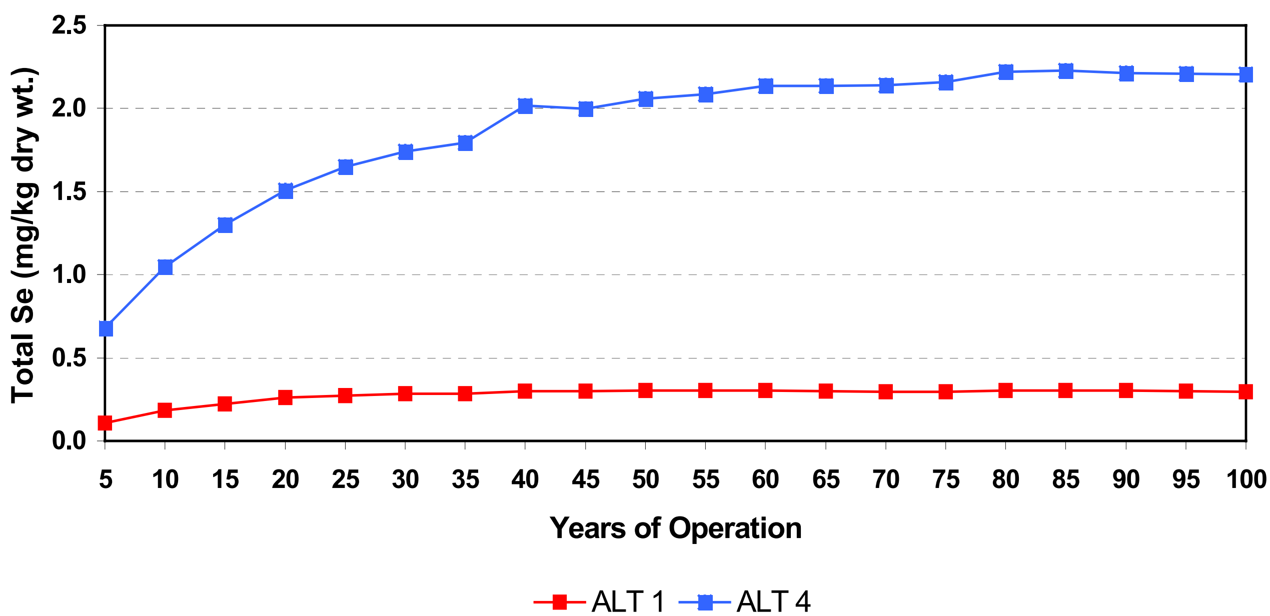
An evaluation of the potential for Se-related impacts associated with a variety of alternatives for chloride control in the Wichita River Basin was conducted by the USACE (2000a). This study involved the use of conservative modeling techniques for estimation of potential future water (Figure 4-3) and sediment (Figure 4-4) Se concentrations in Truscott Brine Disposal Reservoir and comparison of these concentrations with published "threshold" values protective of fish and wildlife as described above. It is important to note that these predictions represent the USACE's best estimate of potential levels under an assumed conservative set of assumptions. As detailed in this document, it is the USACE's opinion that both conservative estimation techniques and use of a lower end of a range of minimum threshold values for protection of all biota lend considerable conservatism to this evaluation in an attempt to address extreme complexity and uncertainty associated with these issues.

FIGURE 4-3
ESTIMATED SELENIUM CONCENTRATIONS IN TRUSCOTT RESERVOIR



Alt 1 – Area VIII – Current Inflow, **Alt 4** – Areas VIII, VII, X - Proposed plan
Source: USACE 2000a

FIGURE 4-4
ESTIMATED SEDIMENT TOTAL SE CONCENTRATIONS IN TRUSCOTT RESERVOIR



Alt 1 – Area VIII only (current), **Alt 4** – Areas VIII, VII, X (proposed plan)
Source: USACE 2000a

Based on results of these studies to date, the USACE concludes that it is reasonable to assume that all alternatives (including the proposed plan) could be implemented without Se-induced impacts on non-breeding birds (e.g., wintering waterfowl) or significant Se-related sediment concerns for these species at Truscott Brine Disposal Reservoir. Also based on results of this evaluation, the USACE concludes that the potential for Se-related impacts to sensitive or moderately-sensitive semi-aquatic bird species breeding at Truscott Brine Disposal Reservoir is conceivable though risks are not believed to be excessive. Whether or not such sensitive species would ever breed at Truscott Brine Disposal Reservoir over the life of the project is uncertain though such species were not observed nesting at the reservoir during extensive breeding bird surveys conducted in 1997 and 1998 (USACE 2001c). Also based on this evaluation, the potential exists for development of waterborne concentrations in Truscott Brine Disposal Reservoir that exceed the current State of Texas 5 μg/l water quality standard after approximately 30 to 35 years of project operation. Given the assumed conservative nature of the approach used, it is likely that realized environmental concentrations would be lower and it would appear that the potential for Se-related impacts predicted by studies to date is not excessive and is low enough that any of the alternatives could be reasonably implemented, provided that an adequate monitoring program accompanies project implementation. Accordingly, the USACE has proposed that both Se monitoring and an interagency process-based action plan for addressing these concerns accompany implementation of any alternative. Both are included in the project EOP (Appendix A).

A balanced analysis of selenium issues for the project should also include a discussion of currently-measured Se-related conditions at Truscott Brine Disposal Reservoir and identification of potential Se-related project benefits. For collection areas, potential in-stream benefits owing to reduced Se loads in brine source streams were previously identified. At the reservoir, extensive monitoring conducted by the USACE (2001d) indicated that following approximately 11 years of project operation, selenium concentrations in water were below concentrations detectable by current analytical techniques (<0.5 μg/l). In addition, Se concentrations in samples of sediment, fish, and limited samples of aquatic vegetation from Truscott Brine Disposal Reservoir were at or below "background" concentrations typical of these media in Se-normal environments as well as below published threshold levels for protection of avian species. As long as these trends continue, Truscott Lake may provide Se-related benefits to the region by providing a low Se aquatic resource in an area characterized by naturally-occurring high selenium in surrounding aquatic systems.

3. Reservoir Volume. Incorporating disposal of brines from all three collection areas into Truscott Brine Disposal Reservoir would result in volumes greater than the original design capacity of the reservoir. The USACE (2000) evaluated rainfall, evaporation, and proposed brine volumes. Rainfall and evaporation data from the period 1962-1999 were used in the volume analysis. Local inflow from precipitation was calculated from changes in storage volumes at Truscott Brine Disposal Reservoir from 1988 through 1999. Design inflow data were then used to obtain a weighted average inflow. Existing flow data were used for inflows from Area VIII while design flow data were used for Areas VII and X. For the proposed plan a final conservation pool elevation of 1502.2 feet NGVD was developed with a spillway elevation of 1505.3 feet NGVD. Maximum pool elevation would be 1510.4 feet NGVD, and the top of the dam would be raised to 1514.9 feet NGVD.

Using spray fields at the intake and outfall points of the brine transport pipelines would minimize changes to Truscott Brine Disposal Reservoir volumes. Each spray field is anticipated to reduce flow volume by 25%. One spray field, for brines from Area VIII, is currently in operation at Truscott Brine Disposal Reservoir and its operation has been used to confirm inflow volume reductions and spray field design. The top of the dam would be raised by construction of a reinforced concrete stem wall. Raising the dam would also flood additional acreage. This construction would potentially occur after 75 years of future operation. During that period, the USACE proposes to monitor the rate of filling and improve the evaporation fields with intent of avoiding further construction and habitat inundation. Predicted land use changes at Truscott are addressed in later sections of this document.

4. Fish Communities. As discussed previously, Truscott Brine Disposal Reservoir presently provides additional habitat for salt tolerant species: Red River pupfish and plains killifish. Salinity in the reservoir changed as the reservoir received brines from the operation of Area VIII components. In 1995, the salinity of the reservoir was 18,000 mg/l (Echelle *et al.* 1995). Operation of the existing and other project components would be expected to continue to increase salinity of the reservoir until an equilibrium is reached, which the USACE has predicted to be less than 100,000 mg/l under the proposed plan. At salinity concentrations less than 100,000 mg/l, the reservoir would continue to provide suitable habitat for the Red River pupfish and the plains killifish. However, if salinity concentrations reach or exceed 100,000 mg/l, the long-term survival of these two species in Truscott Reservoir could potentially diminish or population could be eliminated. The fish communities are one link in the potential transmission of Se to avian species around Truscott Brine Disposal Reservoir. If fish populations are eliminated, Se concerns for fish eating birds would likewise be eliminated.

k. Upper Red River.

1 Stream Water Quality. The Wichita River Basin, with a drainage area of about 3,439 square miles, makes up about 12% of the total drainage area of the Red River and about 14% of the water flow and discharge of chlorides (USACE 2001a). The concentrations of chlorides in the water issuing from the Wichita River Basin average much lower than the Red River. Therefore, the Wichita River flow helps to dilute the water in the Red River, even without the project. However, due to the limited volumetric contribution of the Wichita River, a 50% reduction of chloride loading in the Wichita River would only reduce the concentrations of chlorides in the Red River by approximately 7%. Consequently, stream water quality changes from the proposed project in the Red river would be minimal, with reductions of approximately 10%, 5%, and 7.5% for chloride, sulfates, and TDS, respectively (50% of the time) as calculated at Lake Texoma.

2. Selenium. Implementation of the proposed plan would reduce Se loading to the Upper Red River reaches due to Se removal in the Wichita River Basin and transport to Truscott Brine Disposal Reservoir. Though Se loading would be reduced, benefits would be expected to be minimal for the Upper Red River.

3. Flow. Analysis of flow duration in Reaches 6 and 7 indicated that flow reduction would not be anticipated from implementation of the proposed plan. In addition, because the Wichita River makes up only 14% of the total Upper Red River flow and because flows in the lower Wichita River would be minimally impacted by the project, water quantities in the Upper Red River should be generally unaffected by the proposed project.

4. Upper Red River Fish Communities. Fish populations in the Red River from the confluence of the Wichita River downstream to Lake Texoma (Reaches 6 and 7) would not be affected by implementation of the proposed project. As discussed above, proposed project induced flow changes are not anticipated in the Upper Red River. Therefore, it would be expected that the fish population diversity and density in the Red River from the confluence of the Wichita River downstream to Lake Texoma would not be affected by implementation of the proposed project.

l. Lake Kemp and Lake Diversion.

1. Reservoir Water Quality. Other issues concerning the proposed project and reservoir water quality that were discussed during the scoping process include potential impacts of reduced chlorides, turbidity, and associated impacts on fish populations in Lake Kemp, Texas.

(a) Chloride Concentrations. The principal goal of the proposed project is reduction of naturally-occurring chlorides. Target chloride concentrations of 250 mg/l or less 94% of the time at Lake Texoma and 98% of the time at Lake Kemp were established in the Congressional authorization for the project. However, the proposed project modifications described in this supplement would affect design effectiveness of the original FES plan. The proposed plan is expected to meet the TNRCC secondary drinking water standard of 300 mg/l chloride approximately 40% of the time as shown in Table 4-8.

The degree of chloride control may best be understood in terms of chloride load reductions. For example, out of the total of 244 tons/day of salt produced at Area VII, 195 tons/day would be controlled and prevented from entering Lake Kemp. Out of the total of 189 tons/day of salt produced at Area VIII, 160 tons/day would be prevented from entering Lake Kemp. Out of the total of 58 tons/day of salt produced at Area X, 40 tons/day would be controlled. The total chloride loading controlled by the proposed plan would be 400 tons per day.

Under natural conditions, the chloride concentrations at Lake Kemp equal or exceed 696 mg/l 99% of the time and are greater than 1,312 mg/l 50% of the time. With implementation of the proposed plan, chloride concentrations would equal or exceed 166 mg/l 99% of the time and would be greater than 318 mg/l 50% of the time. This represents a 76% reduction in chloride concentration at Lake Kemp. One of the milestones for chloride concentration reduction is the EPA's secondary drinking water standard for chloride of 250 mg/l. The selected plan is expected to meet this secondary standard 15% of the time. Another milestone is the TNRCC's secondary drinking water standard for chloride of 300 mg/l. The selected plan is expected to meet the TNRCC secondary standard approximately 40% of the time as shown in Table 4-8.

Wichita Falls is expected to begin utilizing Lake Kemp as a municipal drinking water source within the next 3 years. The current Lake Kemp water quality would require the City to blend or treat the water to meet secondary drinking water requirements. Implementation of the proposed plan would result in an economically feasible water resource for the City of Wichita Falls.

TABLE 4-8
LAKE KEMP CONCENTRATION DURATION DATA

	Natural Conditions (No Action Alternative) Percent of Time Equaled or Exceeded								
	1%	**5%**	**10%**	**20%**	**50%**	**80%**	**90%**	**95%**	**99%**
Chlorides (mg/l)	1,985	1,843	1,751	1,628	1,312	1,106	1,016	934	696
Sulfates (mg/l)	953	890	869	838	755	631	575	523	386
TDS (mg/l)	4,650	4,305	4,115	3,838	3,254	2,762	3,515	2,325	1,745

	Proposed Plan (Areas VII, VIII, & X) Percent of Time Equaled or Exceeded								
	1%	**5%**	**10%**	**20%**	**50%**	**80%**	**90%**	**95%**	**99%**
Chlorides (mg/l)	489	434	409	377	318	257	233	212	166
Sulfates (mg/l)	540	510	494	456	395	323	294	268	202
TDS (mg/l)	1,580	1,430	1,343	1,275	1,108	897	815	742	541

Source USACE 2001a

(b) Turbidity. Natural surface waters typically possess suspended materials consisting of nonliving matter (e.g., clays) as well as biological solids (e.g., algae). The presence of suspended material in water causes absorbance, reflection, and scattering of light. The measurement of the extent of this phenomena is referred to as turbidity and is commonly measured in nephelometric turbidity units (NTUs). Nephelometric turbidity is measured in water by use of an instrument known as a turbidimeter suitable for use in field or laboratory settings.

Turbidity is essentially a function of two sets of factors: those that influence the settling rate of suspended materials (settling) and those that may keep suspended materials from settling (mixing). The addition of suspended materials to surface waters can occur as a result of inflows (e.g., during high flow conditions) or as a result of wind-induced re-suspension of sediments from the lake bottom or shorelines. These factors interact to keep a lake within a general range of turbidities characteristic of that lake. Factors that influence settling include type and size of suspended materials, water temperature, and chemical properties of the water, including ionic strength of water as measured by salinity or TDS. Increased TDS can cause an increase in the settling rate of suspended materials by neutralizing ionic forces that keep particles from aggregating and settling (see discussion in Schroeder *et al.* [2000]). Therefore, a TDS reduction of sufficient magnitude could result in decreased settling rates of suspended materials and an associated increase in turbidity in a lake such as Lake Kemp. Factors that influence mixing include wind and wave action, water currents, and lake stratification.

As a result of USACE studies conducted in 1997 and 1999 (Wilde 1999 and Wilde 2000), considerable data are available regarding turbidity levels in Lake Kemp. These reports are available at http://www.swt.usace.army.mil/LIBRARY/Library.CFM. In 1997, average turbidity (n = 858 where n = number of samples) in Lake Kemp was 15 NTU with a range of 1.38 to 90.6 NTU (Wilde 1999). Average turbidity in 1999 was 34.4 NTU (n = 782) with a wide range of 6.2 to 599.0 NTU (Wilde 2000). Accordingly, it is evident that Lake Kemp is a highly turbid lake which is subject to tremendous spatial and temporal variability in turbidity.

A study designed to evaluate site-specific settling rates in Lake Kemp was funded by the USACE and conducted by the USACE Waterways Experiment Station (now ERDC) (Schroeder *et al.* 2000). The study involved collection of water and suspended materials from Lake Kemp and laboratory determination of settling rates at the various TDS levels anticipated for the proposed project. This study is incorporated by reference at http://www.swt.usace.army.mil/LIBRARY/Library.CFM.

Owing to an updated period of record and recent gage data, concentration duration curves (USACE 2001a) for the proposed project are slightly different that those evaluated by Schroeder *et al.* (2000). In order to evaluate potential changes in Lake Kemp turbidity for the proposed plan, impacts of anticipated TDS levels from updated concentration/duration curves (USACE 2001a) were developed for Lake Kemp settling rates. The concentration-duration curves for the proposed plan and No Action alternative were compared using site-specific information and methodology from Schroeder *et al.* (2000). This involved applying regression equations relating TDS concentrations and sedimentation rate constants (Figure 3, Schroeder *et al.* 2000) to proposed plan and No Action alternative TDS concentrations for the three initial turbidity levels (8, 24, and 43 NTU) evaluated by Schroeder *et al.* Once sedimentation rate constants were developed using these methods, first order sedimentation was estimated using the equation:

$$N = N_0 e^{-kt}$$

where N is turbidity at time t, N_0 is the initial turbidity (t = 0), and k is the sedimentation rate constant (1/hr) derived as described above (Schroeder *et al.* 2000). Resulting turbidity values were compared as a measure of the differences in turbidity reduction that might be expected following a "turbidity inducing" event in Lake Kemp. Results were obtained for 1, 5, 50, 95, and 99 "equaled or exceeded" TDS levels as contained in concentration duration-curves (USACE 2001a).

Results of the No Action alternative (natural) and post-project (modified) turbidity reduction evaluations for the 50% "equaled or exceeded" estimate for Lake Kemp are shown in Figures 4-5 (8 NTU), 4-6 (24 NTU) and 4-7 (43 NTU). Schroeder *et al.* (2000) defined "final" turbidity changes as differences in turbidities following 7 days of settling.

For the 8 NTU evaluation, the maximum pre- and post-project turbidity difference is 1.58 NTU after approximately 4 days of settling with an average difference of 1.30 NTU over a 10-day settling period (Figure 4-5). For the 8 NTU evaluation (Figure 4-5), the difference in final turbidity is 1.36 NTU.

For the 24 NTU evaluation (Figure 4-6), the maximum turbidity difference is 4.00 NTU after 3 days of settling with an average difference of 2.85 NTU over a 10-day settling period. Difference in "final" turbidity for this initial turbidity level is 2.56 NTU.

For the very high (43 NTU) evaluation (Figure 4-7), the maximum turbidity difference is 7.5 NTU after 2 days of settling with an average difference of 4.3 NTU over a 10 day settling period. Difference in "final" turbidity is 2.9 NTU.

Based on these analyses, predicted differences in pre- and post- project turbidities for Lake Kemp are relatively minor for a highly turbid reservoir with tremendous variability in turbidity levels.

FIGURE 4-5
PRE- (NAT) AND POST- (MOD) PROJECT TURBIDITY FROM 8 NTU INITIAL TURBIDITY
LAKE KEMP, TEXAS

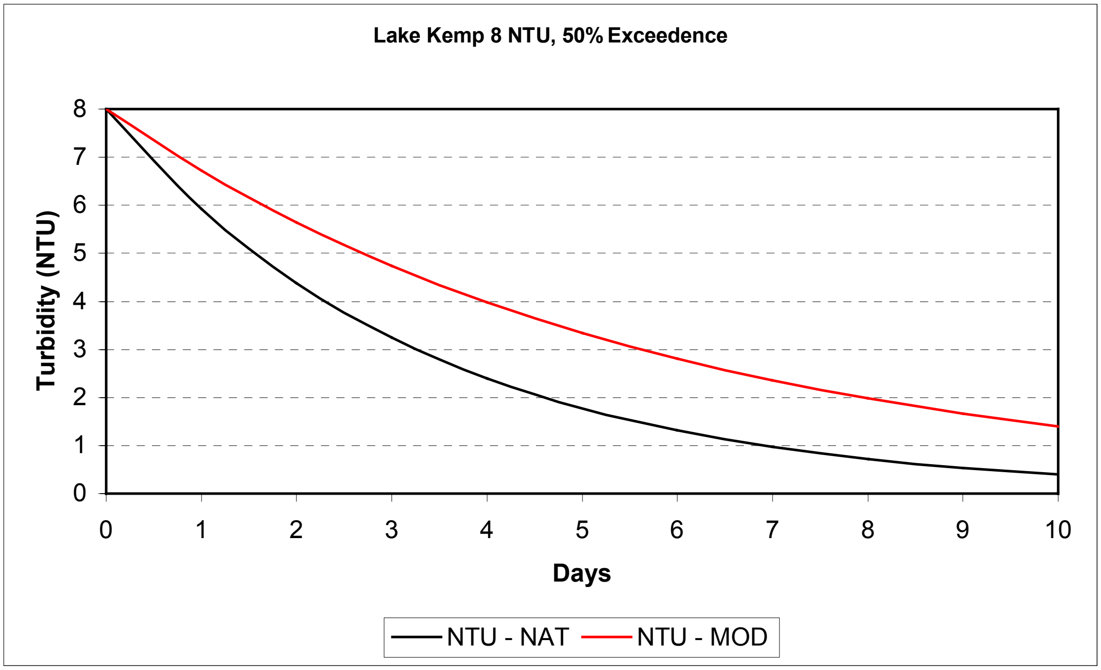


FIGURE 4-6
PRE- (NAT) AND POST-(MOD) PROJECT TURBIDITY FROM 24 NTU INITIAL TURBIDITY
LAKE KEMP, TEXAS

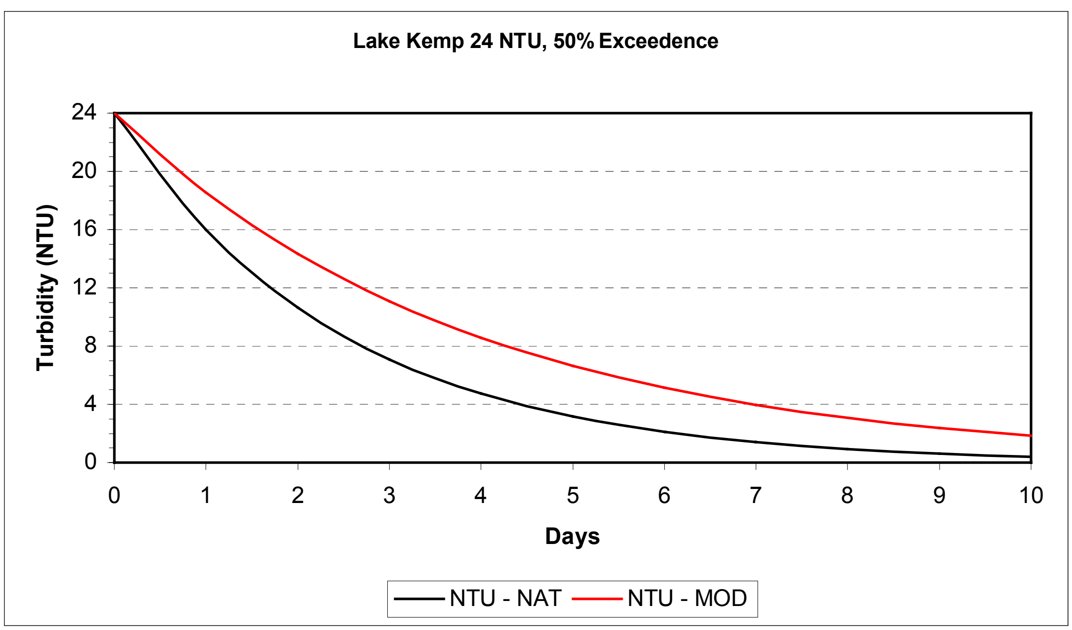
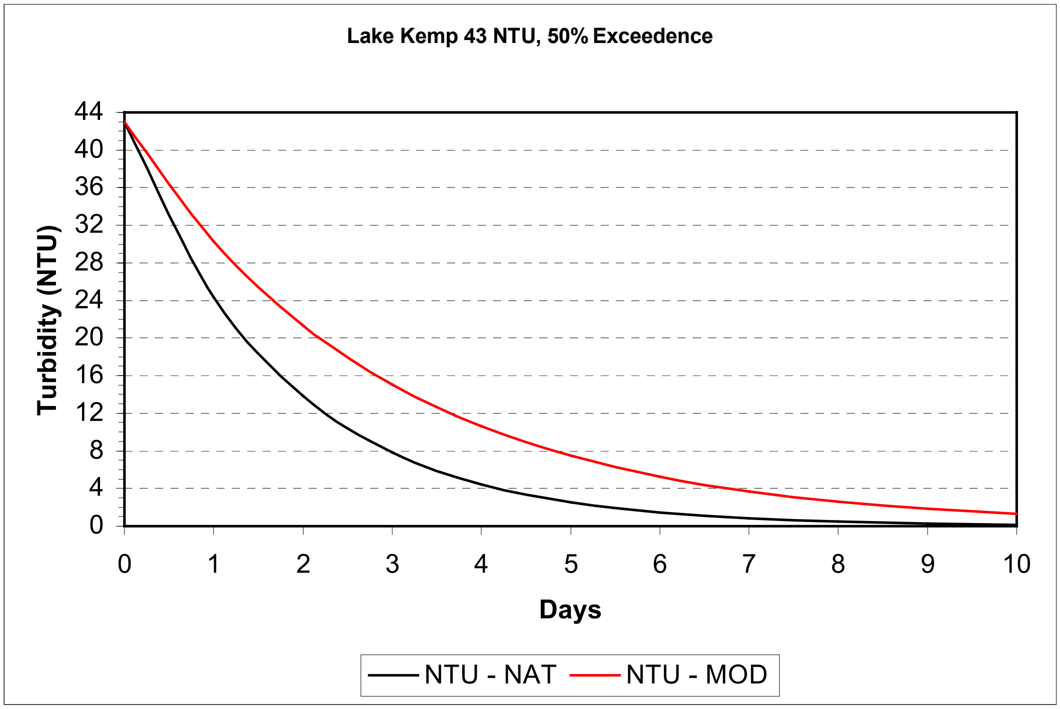


FIGURE 4-7
PRE- (NAT) AND POST-(MOD) PROJECT TURBIDITY FROM 43 NTU INITIAL TURBIDITY
LAKE KEMP, TEXAS



In summary, anticipated changes in solids settling dynamics and turbidity in Lake Kemp were evaluated using site-specific settling data. Resulting differences were estimated to be relatively minor for a highly turbid reservoir subject to significant variability in turbidity levels. Accordingly, project-related impacts associated with turbidity-induced decreases in reservoir primary productivity and associated impacts to the lake fishery are conceivable, though thought to be minor and not presently quantifiable. Monitoring of project-related impacts has been included in the project EOP (Appendix A).

(c) Plankton Dynamics. While it is conceivable that reduced chlorides in Lake Kemp could result in shifts in zooplankton and/or phytoplankton species composition and abundance, environmental factors governing populations of these organisms are extremely complex and difficult to define. While major changes in salinity (marine to fresh water) would most likely result in significant shifts in planktonic assemblages, impacts to plankton associated with the relatively minor magnitudes of chloride reduction associated with the proposed project would be much more difficult to predict. Attempts at integrating the myriad of variables influencing these organisms for purposes of quantifying population changes would be speculative and largely indefensible. Accordingly, impacts on planktonic organisms in Lake Kemp are conceivable, but not quantifiable. Plankton surveys have been included in the EOP (Appendix A) for the proposed project.

(d) Water Quality Impacts to Dundee Hatchery. As previously discussed in Section 3, the TPWD Dundee Fish Hatchery gets its water supply from Lake Diversion. In recent years, it has been significantly impacted by blooms of a toxic alga which has entered the hatchery system. The golden alga, *Prymnesium parvum*, shown in Figure 4-8, is a flagellated yellow-green alga of the class Prymnesiophyceae. It is a common component of marine phytoplankton, and is typically associated with estuaries. It has also been found to be euryhaline and eurythermal (tolerating a wide range of salinities and temperatures, respectively) (Bold and Wynne 1983, Holdway *et al.* 1978). If present in a freshwater environment, these particular attributes allow *P. parvum* to thrive while other fresh water phytoplankton might not. *P. parvum* is also one of the toxic algae, and the released toxin, prymnesia, has a number of effective pathways, including neurotoxicity, hepatoxicity, hemotoxicity, ichthytoxicity and cytotoxicity (Ulitzer and Shilo 1964). The toxin only appears to affect gill-breathing species by causing the gill tissues to become more permeable, and thus more susceptible to the other pathways of the toxin such as the cytotoxic and hemolytic activity (Ulitzer and Shilo 1966). *P. parvum* blooms, however, have had no documented affect on aquatic insects, animals drinking affected waters, or humans (Shilo 1972).

This toxic alga has been associated with numerous fish kills in many parts of the world and was first documented as the cause of fish kills in Texas in 1985. The TPWD has reported approximately 20 fish kills attributed to *P. parvum* since 1985. Estimated fish mortality ranges from 20-30 million individuals since 1985. These blooms have also affected bivalves. Since the 1985 bloom in the Pecos River, the Asiatic clam (*Corbicula fluminea*) is no longer observed (James and De La Cruz 1989). Currently, the range of *P. parvum* has extended into the Pecos, Colorado, Brazos, and Red River systems. In the Red River system, Lake Diversion has been impacted significantly, causing concern in the recreational fishing industry. Lake Diversion supplies the source water and is the site of the TPWD's Dundee Fish Hatchery, which supplies considerable quantities of striped and largemouth bass to stock the states lakes and rivers. In 2001, a *P. parvum* bloom at the hatchery caused the death of the entire year's production of striped bass and most of the brood stock of largemouth bass in the hatchery.

FIGURE 4-8
PRYMENESIUM PARVUM

Toxic algae are extensively studied throughout the world due to their significant impacts on human health, fishing industries, and ecological ecosystems. Algae which have caused the most impact include species such as *Pfiesteria*, a dinoflagellate believed responsible for killing millions of fish from the Chesapeake Bay to the Gulf of Mexico. *Gymnodinium breve* is responsible for red tides and massive fish kills in Florida and Texas. *Alexandrium,* a dinoflagellate present in Puget Sound and on the Pacific Coast, is responsible for paralytic shellfish poisoning in people who eat shellfish that have ingested large amounts of these toxin-producing microscopic algae. *Pseudo-nitzschia*, found on the Pacific Coast, produces domoic acid, which causes amnesiac shellfish poisoning. The toxin produced by this marine diatom can accumulate in both shellfish and fish without apparent ill effects. However, in humans the toxin crosses into the brain and interferes with nerve signal transmission. People poisoned with very high doses of the toxin can die, while lower doses can cause permanent brain damage (short-term memory loss).

Most of the scientific attention and research in the U.S. has focused on these highly visible species of marine algae, where there has been great local and national economic impact. In Europe, however, there has been some effort directed at *P. parvum*, and understanding its biology.

Research has shown no correlation between temperature and production of toxins in *P. parvum* (Shilo, 1972) and Larsen and Bryant (1998) did not find any significant effect on toxicity as a result of variable salinity, light, or temperature conditions. What all researchers agree upon is that *P. parvum* is able to thrive in a wide range of temperatures and salinities, which gives it a competitive advantage over many other species of algae.

Aure and Rey (1991) documented oceanographic conditions in western Norway after a bloom of *P. parvum*, and concluded that a high nitrogen to phosphorous (N: P) ratio with associated P-limitation played an important role in causing the alga to become toxic. Both nitrogen and phosphorous are required for normal algal metabolic processes. N:P implies that phosphorous is undersupplied for normal metabolic processes (i.e., physiological stress).

This was substantiated by Johansson (2000) who described an increase in toxicity due to a decrease in intracellular N or P levels. Further, Johansson showed that toxin production in these species was directly related to physiological stress (Johansson and Graneli 1999; Johansson 2000). Research indicates that the toxicity of *P. parvum* is enhanced when the cells are grown under N- or P-limited conditions, and that the toxins, prymnesins, may play an allelopathic role in the ecosystem (Johansson and Graneli 2000). In other words, the production of prymnesins is favored in *Prymnesium spp.* to suppress the growth of other phytoplankton species, avoid grazing pressure, and thus outcompete other co-occurring phytoplankton species.

Therefore, it appears that a change in the N: P ratio is the governing factor for toxicity in *P. parvum*. In addition, Wynne and Rhee (1988) found that a decrease in phosphate concentrations caused a disruption of the membrane synthesis of *P. parvum* which might lead to leakage of intercellular molecules including toxins. Evidence of a eutrophic, phosphorous-limiting environment in a Moroccan *P. parvum* bloom was documented by Sabour *et al.* (2000), where the water was characterized by elevated total nitrogen, limited nitrates, and undetectable orthophosphates. Freshwater systems tend to be phosphorus limited.

This relationship between the degree of eutrophication and population sizes of *P. parvum* was discussed by Holdway, Watson, and Moss (1978) and holds true with many other species of algae which are prone to large, often toxic, blooms (Finnish Environmental Administration, 2001). Natural eutrophication is the process by which lakes gradually age and become more productive through the gradual increase in the concentration of phosphorus, nitrogen, and other plant nutrients in an aging aquatic ecosystem. It normally takes thousands of years to progress. However, humans, through their various cultural activities, have greatly accelerated this process in thousands of lakes around the globe. Cultural or anthropogenic "eutrophication" is water pollution caused by excessive nutrients. Humans add excessive amounts of plant nutrients (primarily phosphorus, nitrogen, and carbon) to streams and lakes in various ways. Runoff from agricultural fields, feed lots, urban lawns, and golf courses is a major source of these nutrients. Untreated, or partially-treated, domestic sewage is another major source. The combustion of fossil fuels, and industrial and agricultural discharges of N-containing gases, aerosols, and air-borne particles contribute to the atmospheric nitrogen load. Evidence suggests that the atmospheric deposition of nitrogen in water bodies (directly and via rainfall) constitutes a large portion of total nitrogenous inputs to estuarine and marine systems and a somewhat lesser portion of total N inputs to freshwater systems (Paerl 1993). Additional nitrate and phosphorus sources include excreta from wild animals in surrounding watersheds and excreta from waterfowl that congregate on the water body.

Texas blooms (as opposed to toxin production) of this species also seem to be related to temperature in that most of the confirmed Texas blooms of *P. parvum* occurred between October and January, with a couple starting as early as August and two starting in March and April, respectively. A preliminary review of departure from normal average temperature data (available at http://www.ncdc.noaa.gov) for the confirmed *P. parvum* blooms showed they coincided with either a higher or a lower average temperature than normal for that month. If there is already a trend towards increasing nutrient levels due to run off, then a change in temperature norms, these factors together could favor a bloom of *P. parvum* over other species due to its tolerance of extremes and competitive nature.

During the most recent bloom of *P. parvum* at the Dundee Hatchery, ammonia concentrations were less than or equal to 0.1 mg/l at all six water outfalls from the hatchery. Nitrate nitrogen was below detectable limits. Kjeldahl nitrogen averaged 1.5 mg/l, with a range of 0.8 to 2.5. Phosphorus averaged 0.014 with a range of 0.001 to 0.031 mg/l. All of these data are for single points in time at the six outfalls. In addition, ammonia and phosphorus was measured in channel catfish production ponds. Ammonia averaged 0.22 mg/l and ranged from 0.01 to 1.4 mg/l. Phosphate averaged 0.012 mg/l and ranged from 0.005 to 0.023 mg/l (Joe Warren, Personal Communication, 2002). This limited data indicates that ammonia levels, in the grab sample result above, were higher inside the channel catfish production ponds than in the discharge water at the time of sampling. In addition, phosphorous levels were lower inside the hatchery than in the discharge water water. At the time of blooms at the Dundee Hatchery, similar blooms were not noted either in Lake Diversion or downstream of the hatchery in the Wichita River. This may indicate that N:P ratios were increased inside the hatchery favoring *P. parvum* toxicity.

The focus of the proposed project is to control the natural salinity loading of the Wichita River system, to provide economically available water supplies for municipal, industrial and agricultural use. The proposed project, if fully implemented, would result in decreasing salinity in the Wichita River.

Salinity changes would probably not have a direct effect on blooms of *P. parvum* (as shown by Larsen and Bryant 1988). However, salinity decreases may favor native algal species. Conversely, if toxin production is directly related to physiological stress, as previously noted, then changes in salinity may increase production of toxins in *P. parvum*. In addition to these factors, the hatchery may be affected internally by nutrient concentrations, particularly if unbalanced N:P ratios are present within the hatchery due to excreta and unconsumed food. These conditions, though not a result of the proposed project, may encourage toxic blooms of *P. parvum*. When these conditions, especially combined with temperature anomalies, are present, *P. parvum* is likely to bloom and produce toxins. At the present time, impacts from the proposed project on golden algae toxicity at the Dundee State Fish Hatchery are speculative and may be either beneficial or adverse.

2. Flow to Lake Kemp and Lake Diversion. The project also has the potential to impact Lake Kemp storage by decreasing inflow and increasing water use due to improved water quality.

Based on data obtained from the USACE 2000 Annual Report (USACE 2000b), the long-term average inflow for Lake Kemp is 188,600 acre feet/year. This long term average is based on a period of record from 1924 to 2000. The average annual inflow for the period of record, 1962-1998, used in the low flow/concentration duration analysis is 177,153 acre feet/year. A review of inflows from 1988-2000 for Lake Kemp, the period of record after construction of Area VIII, reveals an average annual inflow of 186,952 acre-feet/year. This indicates that the removal of brine flows from the upper reaches of the basin have had minor effects on the inflow into Lake Kemp, but a change in weather patterns may have caused the 1% change.

The proposed plan is expected to increase water demands on Lake Kemp due to improved water quality. Water usage under the proposed plan model was increased by 61,222 acre-feet/year for simulation purposes as shown in the following sections. Pool elevation duration data indicates that under existing conditions Lake Kemp is at or above elevation 1135 feet NGVD 91.2% of the time. Under the proposed plan with brush control implemented at the Truscott gage, Lake Kemp is expected to be at or above 1135 feet NGVD 48.0% to 48.6% of the time. With brush control implemented in 50% of the entire basin (including mitigation brush control above Truscott gage), Lake Kemp is expected to be at or above elevation 1135 feet NGVD 51.5% to 53.8% of the time. The increased water demand on Lake Kemp under the proposed plan would result in wider fluctuations in elevation. These wider elevation fluctuations should not be interpreted to mean that insufficient storage is available to meet future water demands at Lake Kemp. As the duration data indicates, Lake Kemp would experience lower elevations during dry weather periods and would recover as wetter periods are experienced.

(a) Future Irrigation and M&I Impacts on Lake Kemp. Increased irrigation and municipal/industrial water usage is projected for Lake Kemp after project construction due to improved water quality. Existing and future water usage is presented in Table 4-9.

TABLE 4-9
EXISTING AND PROJECTED WATER USAGE IN LAKE KEMP

Water Supply User	Existing Water Usage Acre-Feet/Year	Projected Water Usage Acre-Feet/Year
Irrigation	80,000	120,000
Municipal	0	11,222
Industrial	10,000	20,000
Recreation	5,850	5,850
TPWD Hatchery	2,200	2,200

Source: USACE 2001a

(b) Elevations and Drought Contingency. The Wichita County Water Improvement District No. 2 was required by Texas Senate Bill 1 to develop and implement a drought contingency plan for Lake Kemp. The drought contingency plan created action levels that required reductions in water usage at specific elevations. The drought contingency requirements are listed below in Table 4-10.

TABLE 4-10
LAKE KEMP /DIVERSION DROUGHT CONTINGENCY

	Elevation 1145.0 (NGVD)	Elevation 1123.0 (NGVD)	Elevation 1114.0 (NGVD)	Elevation 1109.0 (NGVD)
Irrigation	100%	50%	25%	0%
Municipal	100%	100%	100%	100%
Industrial	100%	100%	100%	100%
Recreation	100%	0%	0%	0%
TPWD Hatchery	100%	0%	0%	0%

Source: USACE 2001a

A study was made of existing conditions and the proposed plan with 50% brush control below the collection areas at Areas VII, VIII, and X and above Lake Kemp. Pool elevation duration results for selected elevations are included in Table 4-10. Implementation of the brush control program for 50% of the area above Lake Kemp and below the collection areas would effectively change the without-project future conditions. The increase in inflows as a result of the brush control program would increase the elevation duration. Table 4-10 indicates that under existing conditions, the elevation at Lake Kemp would equal or exceed elevation 1144 feet NGVD 29.3% of the time. Under the future condition (50% brush control), Lake Kemp would exceed elevation 1144 feet NGVD 31.4% to 33.3% of the time, an increase of 2.1 to 4.0%.

Under existing conditions, annual water usage was assumed to be 98,050 acre-feet/year (see Table 4-9). The proposed plan would increase water usage to 159,272 acre feet per year, a difference of 61,222 acre feet. As a result of increased water usage, elevations at Lake Kemp would equal or exceed elevation 1144 only 10.7% to 11.4% of the time with the proposed plan in operation and 50% brush control at the Truscott gage. This represents a decrease of 18.6 to 17.9% in duration from existing conditions. With the proposed plan and 50% brush control throughout the Wichita River Basin, Lake Kemp would be at or above elevation 1144 feet NGVD 13.2% to 14.3% of the time, a decrease of 16.1% to 15.0% in duration from existing conditions.

Under the proposed plan an estimated 159,272 acre-feet per year was simulated to be released from Lake Kemp. This annual total would be a maximum that is projected to occur during the driest conditions. The elevation duration estimates listed in Table 4-11 should be viewed as conservative estimates. Under actual conditions, Lake Kemp elevations are expected to be higher.

TABLE 4-11
LAKE KEMP ELEVATION DURATION DATA

	Percent of Time Equaled or Exceeded							
Elevation (NGVD)	**1114**	**1120**	**1123**	**1125**	**1130**	**1135**	**1140**	**1144**
Existing Conditions	100	100	100	99.8	99.3	91.2	70.1	29.3
Existing Conditions w/ 50% Brush Control -27.6%	100	100	100	100	99.5	94.0	73.3	31.4
Existing Conditions w/ 50% Brush Control – 38.9%	100	100	100	100	99.5	95.9	74.1	33.3
Proposed Plan w/ 50% Brush Control @ Truscott Gage– 27.6%	98.9	89.3	83.1	75.9	63.3	48.0	24.7	10.7
Proposed Plan w/ 50% Brush Control @ Truscott Gage– 38.9%	98.9	98.9	83.9	76.7	63.7	48.6	25.0	11.4
Proposed Plan w/ 50% Basin Brush Control 27.6%	99.3	91.4	85.2	78.9	66.5	51.5	29.4	13.2
Proposed Plan w/ 50% Basin Brush Control 38.9%	99.7	92.4	88.3	82.1	69.8	53.8	32.7	14.3

Source: USACE 2001a

Based on the period of record used in the low flow/concentration duration study, Lake Kemp has an average annual inflow of 177,153 acre-feet/year. Brush control program application for 50% of the Truscott gage basin is estimated to increase inflows into Lake Kemp by 2.2 to 3.2%. Brush control application for 50% of the basin above Lake Kemp is expected to increase inflows 8.4 to 11.9%. Table 4-12 represents Lake Kemp inflow data.

TABLE 4-12
LAKE KEMP AVERAGE ANNUAL INFLOWS

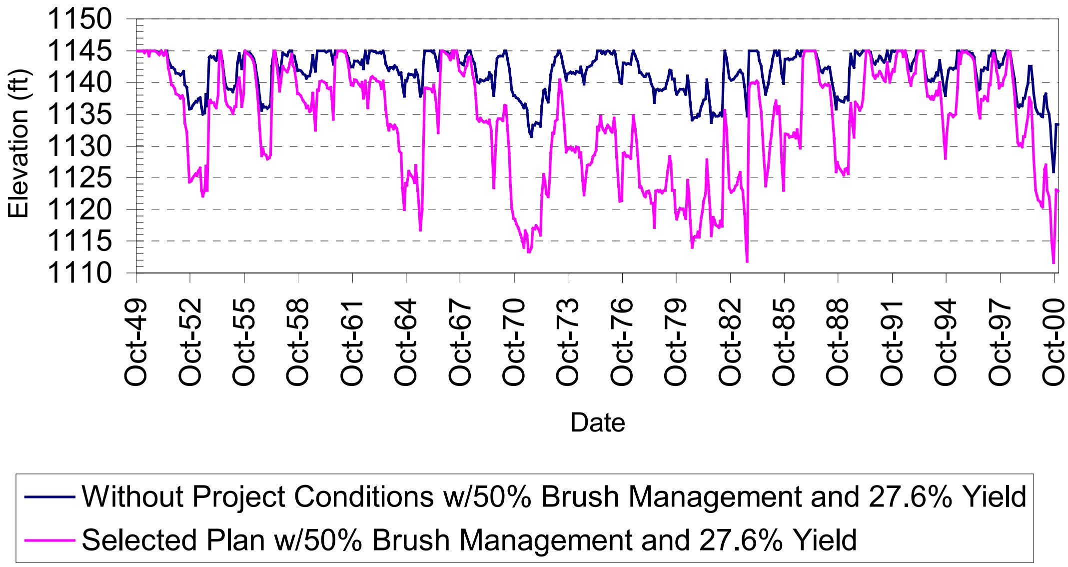
	Average Annual Inflow (Acre Feet)	Difference From Existing (Acre Feet)	Percent Difference From Existing
Existing Conditions	**177,153**	**-**	**-**
Proposed Plan w/ 50% Brush Control @ Truscott Gage – 27.6%	**181,051**	**3,874**	**2.2%**
Proposed Plan w. 50% Brush Control @ Truscott Gage – 38.9%	**182,822**	**5,669**	**3.2%**
Proposed Plan w/ 50% Basin Brush Control - 27.6%	**192,034**	**14,881**	**8.4%**
Proposed Plan w/ 50% Basin Brush Control - 38.9%	**198,235**	**21,081**	**11.9%**

Source: USACE 2001a

(c) Water Supply Impacts to Dundee Fish Hatchery. Under the Lake Kemp Drought Contingency Plan, the TPWD's Dundee Fish Hatchery below Lake Diversion would not receive water from Lake Diversion when Lake Kemp is below elevation 1123. Under the selected plan with 50% brush control at Truscott, Lake Kemp is at or above elevation 1123 83.1% to 83.9% of the time. With brush control implemented in 50% of the basin, Lake Kemp is at or above elevation 1123 85.2% to 88.3% of the time.

Examination of the elevation hydrograph for Lake Kemp (Figure 4-11) reveals that over the period of record October 1, 1949, through December, 31, 2000, elevation model outputs predict that elevation fluctuations in the lake would have differed between the No Action and proposed plans. Examination of the historical (current conditions in the basin without brush management) elevation durations (January 1, 1960, through December 31, 2000) indicate that the elevation at Lake Kemp equaled or exceeded 1123 feet NGVD 100% of the time, indicating that in any given year the Dundee State Fish Hatchery experienced a 0% chance of contractual water supply loss. Under the No Action Alternative, the risk that the hatchery would experience a contractual loss of water supply would continue to remain 0%. Under the proposed plan the potential to meet the contractual agreement conditions increases to between 11.7 and 14.8%.

FIGURE 4-9
LAKE KEMP ELEVATION HYDROGRAPH



Elevation controls for hatchery water supply did not exist until development of Senate Bill 1 in 1999 and is not based upon actual water availability. This is a contractual issue established with the Wichita County Water Improvement District No. 2, the City of Wichita Falls, and the TPWD and documented in legislation. During drought contingency conditions, water continues to be available from Lake Diversion for municipal and industrial use for a fee further documenting that water supply is available. Contracts for fee payment or waiver could be developed to allow the Dundee Fish Hatchery to utilize water from Lake Diversion under drought contingency conditions.

Lakes Kemp and Diversion are operated as part of the Wichita County Water Improvement District No. 2 irrigation system. Lake Kemp provides the storage and yield required for irrigation withdrawals and Lake Diversion provides the elevation necessary for delivery of water to the canal system. All releases from Lake Kemp travel down the Wichita River to Lake Diversion. During normal operations, the Lake Diversion conservation pool is maintained within 1 to 2 feet of the spillway crest (elevation 1052). Floodwater is discharged through the spillway and travels down the Wichita River. Irrigation releases are made through six gates into the irrigation canal.

The outlets from Lake Diversion to the Dundee Hatchery consist of a 14-inch outlet at elevation 1047 and a 3-inch siphon outlet at elevation 1049. According to Wichita County Water Improvement District No. 2, the 14-inch outlet does not supply enough water, so the hatchery depends on the 30-inch outlet. The Water Improvement District must maintain Lake Diversion between elevation 1050 to 1052 year round to ensure the Dundee Hatchery an uninterrupted water supply. According to Wichita County Water Improvement District No. 2 personnel, if Lake Diversion were allowed to lower their elevation during the non-irrigation season, the Lake Kemp/Diversion system could increase yield by as much as 10,000 acre-feet-per-year.

Based upon analysis of water supply features at the Dundee Fish Hatchery, issues resulting from temporary elevation decreases in Lake Kemp or Lake Diversion can be addressed by administrative means. Changes to the Drought Contingency Plan could be accomplished through the legislative process or through the RRA, which has delegated authority for the Drought Contingency Plan in Water Planning Region B. Additional contractual negotiations could be conducted between the Wichita County Water Improvement District No. 2 and the TPWD for fee payment or waiver for water use during drought contingency conditions.

3. Lake Kemp Fish Communities. Factors that could be affected by implementation of the proposed project that could, in turn, affect the composition and quality of the fish community in Lake Kemp include water quality and the quantity and quality of fish habitat in the lake. Water quality changes in Lake Kemp that would be expected with the proposed action have been discussed previously.

(a) Fish Habitat. The quantity and availability of habitat required by fishes and other aquatic organisms present in Lake Kemp can be highly dependent upon the lake's elevation. The lake elevation affects habitat availability as well as spawning and recruitment success. During the spawning season, nest site selection, nest construction, and spawning can be adversely affected by reservoir drawdown (Baxter 1977). Largemouth bass, crappie, bluegill, and catfishes are the primary sport fish in the reservoir that could be affected by reservoir drawdown during their spawning period. For majority of the sport fish species (except catfish) in Lake Kemp, the spawning season starts in March and is completed by the end of May. Striped bass are not known to spawn in the Wichita River, and the population in Lake Kemp is maintained through intensive stocking. While stocking of largemouth bass in Lake Kemp has taken place in the past, recruitment rates have been sufficient to maintain this component of the sport fishery. The stocking of Florida largemouth in recent years has been undertaken with the goal of increasing the Florida bass allele frequency in the population as well as recruitment rates (TPWD 1999).

Lake elevation duration analysis for the period of record (October 1949 though December 2000) was performed with three assumptions:

- The top of the conservation pool in Lake Kemp is 1144 feet NGVD,
- Flood control storage between 1144 feet and 1145 feet NGVD is managed for a controlled drawdown to maximize water supply availability for municipal, industrial, and irrigation uses, and
- Brush management in the Wichita River Basin between all three collection areas and Lake Kemp is expected to be implemented within about 50% average of the basin area as part of the state water plan over the project life. Brush management is a without-project base condition.

Occasionally (not more than 13.1% of the time), the elevation of Lake Kemp is higher than 1144 feet NGVD (top of conservation pool) but less than 1145 feet NGVD (first foot of flood control storage). With this in mind, elevation duration models under proposed project and No Action alternative conditions were constructed assuming an effective storage pool elevation in Lake Kemp of 1145 feet NGVD. Brush management plans formulated by the RRA in cooperation with the TSSWCB have projected an increase in overall watershed yield per area of brush management to range between 27.6% and 38.9% (RRA 2000). Elevation duration and hydrograph analyses incorporated into the elevation model, were based on an estimate of 50% achievement in brush management and used the more conservative watershed yield estimate of 27.6%.

Lake elevation fluctuations from the most recent 10-year period of record (January 1991 through December 2000) under both proposed project and No Action alternative conditions were evaluated to determine if elevation fluctuations during the spawning season would hinder nest construction and spawning. The 10-year period of record used in this evaluation was chosen so that the most recent TPWD fisheries surveys could be incorporated into the impact assessment. As shown on Table 4-13, fluctuations in the reservoir's elevation during the spawning season was predicted to be quite similar with the No Action alternative and the proposed plan (-3.18 to +2.79 feet vs. –4.57 to +9.35). These data suggest that during the spawning season, elevations remain relatively stable and spawning would not be affected by the proposed project. Based on TPWD estimates of population stability and spawning success in Lake Kemp (TPWD 1993; 1996; 1999), habitat (gravel and rocky shoreline) is available in sufficient quantities that the proposed action would not impact spawning success rates of sport fish species in the lake. However, elevation fluctuations during flood and drought events could possibly delay and/or contribute to unsuccessful spawning during the year of the event regardless of proposed project implementation.

TABLE 4-13
USACE PROJECTIONS OF LAKE KEMP ELEVATION FLUCTUATIONS, MARCH THROUGH JUNE

Year	Current Conditions*	Proposed Project Conditions*
1990	0	(4.57)
1991	1.41	2.17
1992	(0.36)	0
1993	0	0
1994	0.47	(1.11)
1995	2.79	9.35
1996	(3.18)	(5.24)
1997	(0.85)	5.43
1998	(2.64)	(4.11)
1999	1.97	(3.52)
2000	(2.8)	(4.32)

*50% Brush Management and 27.6% Watershed Yield

Emergent aquatic vegetation and submerged terrestrial vegetation are generally considered the most critical littoral zone habitat required for the survival of young fish (successful recruitment). In Lake Kemp, emergent aquatic vegetation and submerged terrestrial vegetation comprise 0.2% and 21.4%, respectively, of the littoral zone when the reservoir is at elevation 1144 feet NGVD. However, neither habitat type is present in the littoral zone when the reservoir is at elevation 1136.4 feet NGVD (Table 4-14).

Elevation duration predictions based on period of record (October 1961 through September 1998) predict that with the No Action alternative Lake Kemp would be at or above elevation 1144 feet NGVD approximately 33% of the time and with the proposed plan this elevation is achieved only 13% of the time. After the 1995 littoral zone habitat survey, which was conducted when the reservoir's pool elevation was 1144 feet NGVD, the TPWD indicated that habitat for successful recruitment was extremely limited in Lake

Kemp (TPWD 1996). When the reservoir is full (elevation 1144 feet NGVD or higher), most of the desired habitat is provided by submerged terrestrial vegetation (21.4% of the 21.6 % provided by the two habitats). However, the pool elevation only has to drop a foot or two and submerged terrestrial vegetation is no longer available for fish to use. Presently, recruitment of sport fish in Lake Kemp is being adversely affected by the lack of desired littoral zone habitat, and this condition would continue with the implementation of the proposed project.

Habitat alteration can be implemented to mitigate for recruitment and shoreline habitat loss. Bush rows around selected coves would be provided to allow for successful recruitment. Also, if warranted, periodic stocking of individuals of affected species could assist in mitigating this potential impact. This alternative would most likely be implemented on a local level with coordination through the USACE. Benefits would be realized through improvements in spawning and recruitment habitat.

TABLE 4-14
LAKE KEMP LITTORAL HABITAT TYPES

	1995 (Elevation 1144.0)			1998 (Elevation 1136.5)		
Littoral habitat type	**Miles**	**Percent of total**	**Acreage**	**Miles**	**Percent of total**	**Acreage**
Riprap	9.2	8.3		0.4	0.6	
Rocky shoreline	65.6	59.4		34.1	48.5	
Eroded bank	8.6	7.8				
Sandy beach	0.4	0.4				
Flooded terrestrial vegetation	23.6	21.4				
Emergent vegetation	0.2	0.2	< 1			
Featureless	1.6	1.4		13.7	19.5	
Gravel shoreline				22.1	31.4	
Total shoreline length	110.4					
Habitat adjacent to shoreline						
Standing timber	57		730	10.6		418
Boat docks	22			3.2		76

Source: TPWD 1996, 1999

4. Lake Diversion Fish Communities. Factors that could be affected by the implementation of the proposed action that could in turn affect the composition and quality of the fish community in Lake Diversion are the same as discussed for Lake Kemp.

As discussed previously for Lake Kemp, changes in reservoir level and/or frequency of fluctuations are the primary way that project induced changes could affect fish habitat in these reservoirs. Lake Diversion experiences only minor fluctuations (annually or between years) in pool elevation and that are less than two-feet. With the relative stable water elevation, a high portion of the littoral zone of the reservoir has emergent and submerged vegetation that provide needed habitat for the successful recruitment of many sport fish species. Under the proposed plan, it is expected that the fluctuation of the pool elevation of Lake Diversion would not change substantially from pre-project fluctuations.

Therefore, the proposed plan is not expected to affect the fish habitat in Lake Diversion and the lake would be expected to provide continued fishing opportunities for catfish (blue and channel), crappie, and bass (striped, largemouth, and white bass).

5. Kemp/Diversion Recreation. Some members of the public and resource agencies have expressed concern about the changes in water quality in the Wichita River and its impact on water-based recreation. Changes in water quality may result in changes in the clarity, or turbidity, of bodies of water popular with recreation users such as Lake Kemp. Lake Kemp is a resource accessible only through private property; however, visitors use the lake for recreation. In response to concerns about recreation at the lake, the USACE contracted with Texas Tech University Department of Range, Wildlife, and Fisheries Management to assess the economic value of recreation at Lake Kemp and assess potential impacts to the value of recreation because of projected related changes. The study estimated the impacts of Lake Kemp recreation expenditures in the areas surrounding the lake.

It is well known that water clarity affects the value of water-based recreation (Carson and Mitchell 1998). Chizinski *et al.* (2001) used the contingent value method to quantify the current recreation value and expected changes in value with changes in water clarity. According to the Chizinski *et al.* (2001) report, survey respondents were asked a series of questions concerning how their valuation of recreation would change with changes of water clarity at the lake. Based on this data, an increase in turbidity from 10 to 100 NTU would be discernable to recreational users and would result in an annual loss in consumer surplus. During the course of the Chizinski research, recreation users were unable to differentiate preferences for turbidity levels between 100 and 1000 NTU and such would not result in a loss in consumer surplus.

Subsequent research (Schroeder *et al.* 2000) has clarified the nature of turbidity levels at Lake Kemp. Further analysis of this research indicates that the changes in turbidity at Lake Kemp between pre- and post- project may not be discernable to most recreation users. Predicted changes in turbidity associated with the project are relatively minor for a highly turbid lake, with variable pre-project turbidity levels. Such a difference is unlikely to affect the aesthetics or productivity of the Lake Kemp recreational resources. Based on project differences between the pre- and post-project turbidity, the impact to recreational use and the value of recreation under the with- project condition is below a level that can likely be identified by recreation users. Consequently there would be no discernable impacts to recreation users at Lake Kemp resulting from decreased salt concentrations.

The Chizinski *et al.* (2001) study found that Lake Kemp recreation spending accounted for $425,269 of expenditures in Baylor County, $983,664 of expenditures in a 10-county region surrounding Lake Kemp and $1,508,471 of expenditures in the state of Texas. These are expenditures related to Lake Kemp use. These expenditures are not solely attributable to the availability of Lake Kemp as a recreation resource, as there are a number of other substitutes for Lake Kemp expenditures, including other forms of recreation and expenditures.

m. Lake Texoma.

1. Reservoir Water Quality. Concerns for project effects on reservoir water quality are the same for both Lake Kemp and Lake Texoma, and the general discussion of water quality above applies to both lakes. Due to the significance of the striped bass fishery at Lake Texoma, additional studies of that lake have been performed.

(a) Chloride Concentrations. The principal goal of the proposed project is reduction of naturally occurring chlorides in the Wichita River and Lake Kemp. The Red River Basin has an estimated total chloride load of 3,300 tons/day. The proposed plan would remove 362 tons/day resulting in an 8.9% reduction in total chloride load for the Red River Basin. The proposed project modifications described in this supplement would reduce, to a high degree, the chloride impacts at Lake Texoma as compared to the original FES plan.

Lake Texoma has already experienced chloride reductions from implementation of Area VIII and removal of man-made brine sources. The RRA (1994) reports that from 1974-1990 approximately 16.3% of the natural chloride load from the major source areas and 84.6% of the man-made chloride load have been removed from the Red River. Construction of Area VIII alone resulted in a 4% reduction in chlorides at Lake Texoma (USACE 2001a). These historical changes establish without-project conditions. Since implementation of these chloride reduction measures, anecdotal evidence suggests that no adverse impacts to fisheries and turbidity have been experienced.

The concentration duration study revealed that under natural conditions, the chloride concentrations at Lake Texoma (Denison gage) equal or exceed 165 mg/l 99% of the time and are greater than 345 mg/l 50% of the time (USACE 2001a). With implementation of the proposed project, chloride concentrations would equal or exceed 147 mg/l 99% of the time and would be greater than 309 mg/l 50% of the time (USACE 2001a). This represents a 10% reduction in chloride concentrations at Lake Texoma. Table 4-15 presents Lake Texoma concentration data.

The limited nature of the changes to Lake Texoma chloride concentrations is due to the project's reduced scope, which is limited to the Wichita River. The Wichita River Basin, with a drainage area of about 3,439 square miles, makes up about 12% of the total drainage area of the Red River and about 14% of the water flow and discharge of chlorides. The concentrations of chlorides in the water issuing from the Wichita River Basin average much lower than the Red River. Therefore, the Wichita River flow helps dilute the water in the Red River, even without the project. However, due to the limited volumetric contribution of the Wichita River, a hypothetical 50% reduction of chlorides in the Wichita River would only reduce the concentrations of chlorides in the Red River by about 7%. Hence, the proposed project has a low ability to affect chloride concentrations in Lake Texoma, an impoundment of the Red River. Consequently, water quality improvement at Lake Texoma would be minimal, with reductions of approximately 10%, 5%, and 7.5% for chloride, sulfates, and TDS, respectively at the 50% exceedence level.

TABLE 4-15

LAKE TEXOMA CONCENTRATION DURATION DATA

	No Action alternative Percent of Time Equaled or Exceeded								
	1%	**5%**	**10%**	**20%**	**50%**	**80%**	**90%**	**95%**	**99%**
Chlorides (mg/l)	469	436	423	409	345	271	241	216	165
Sulfates (mg/l)	315	301	289	273	228	164	146	129	91
TDS (mg/l)	1,294	1,234	1,207	1,166	995	791	722	634	474
	Proposed plan (Areas VII, VIII, & X) Percent of Time Equaled or Exceeded								
	1%	**5%**	**10%**	**20%**	**50%**	**80%**	**90%**	**95%**	**99%**
Chlorides (mg/l)	417	391	376	365	309	245	215	192	147
Sulfates (mg/l)	296	283	273	257	217	155	138	123	87
TDS (mg/l)	1,190	1,136	1,109	1,075	921	730	665	582	435

Source: USACE 2001a

(b) Turbidity: An issue of particular importance for this project involves potential increases in lake turbidity (a measure of water clarity) resulting from decreased dissolved salt concentrations in Lake Texoma. Of significant concern would be the potential for decreased water clarity to result in reduced reservoir productivity with associated impacts on abundance and harvest of Lake Texoma sport fishes. In addition, turbidity increases could lead to a loss of aesthetic value of the lake and impacts on recreational use, local economics, and tourism associated with this popular reservoir. Accordingly, studies have been conducted by the USACE to address these issues. Findings of these studies are summarized in this section.

Natural surface waters typically possess suspended materials consisting of nonliving matter (e.g., clays) as well as biological solids (e.g., algae). The presence of suspended material in water causes absorbance, reflection, and scattering of light. The measurement of the extent of this phenomenon is referred to as turbidity and is commonly measured in nephelometric turbidity units (NTUs). Nephelometric turbidity is measured in water by use of an instrument known as a turbidimeter which may be employed in field or laboratory settings. A field turbidimeter in common use for these measurements has a typical accuracy range of +/- 5% of the reading or 2 NTU (whichever is greater) with a resolution of 0.1 NTU (YSI Incorporated 2001). As a point of reference, the State of Oklahoma surface water quality standard for turbidity is 25 NTU.

Turbidity is essentially a function of two sets of factors: those that influence the settling rate of suspended materials (settling) and those that may keep suspended materials from settling (mixing). The addition of suspended materials to surface waters can occur as a result of inflows (e.g., during high flow conditions) or as a result of wind-induced re-suspension of sediments from the lake bottom or shorelines. These factors interact to keep a lake within a general range of turbidities characteristic of that lake. Factors that influence settling include type and size of suspended materials, water temperature, and chemical properties of the water, including ionic strength of water as measured by salinity or TDS. Increased TDS can cause an increase in the settling rate of suspended materials by neutralizing ionic forces that keep particles from aggregating and settling (see discussion in Schroeder and Toro [1996]). Therefore, a TDS reduction of sufficient magnitude could result in decreased settling rates of suspended materials and an associated increase in turbidity in a lake such as Lake Texoma. Factors that influence mixing include wind and wave action, water currents, and lake stratification.

As a result of USACE studies, considerable data are available regarding turbidity levels in Lake Texoma. Included are results of extensive sampling by the University of North Texas from August 1996 to September 1997 (Atkinson *et al.* 1999) as well as more recent unpublished data collected from March 1999 to June 2000. Based on these measurements, collected at a variety of locations across the lake, estimated mean and median turbidities for the lake are approximately 10 and 6 NTU, respectively (n = 262). Turbidity levels in the lake for the same study periods were highly variable, ranging from 1.3 to 90.4 NTU. Accordingly, Lake Texoma can be described as a moderately turbid lake with an extremely high degree of spatial and temporal variability in turbidity.

Estimates of potential changes in water clarity, algal productivity, and resulting impacts on sport fish harvest in Lake Texoma for the entire original RRCCP were provided by Gade *et al.* (1992). They estimated that a reduction in chlorides associated with implementation of the entire RRCCP (45% reduction in chlorides) could result in a minor reduction in chlorophyll *a,* a surrogate estimate of algal abundance, but that a statistically significant reduction in whole-lake chlorophyll *a* would not be anticipated. Despite these findings, the authors went on to conservatively estimate an approximate 8% reduction in sport fish harvest with full implementation of the original RRCCP.

Gade *et al.* (1992) used settling rates extrapolated from the literature. Use of these extrapolated values and a lack of site-specific settling data were identified as shortcomings of this study by the Lake Texoma Workgroup during the Environmental Issue Resolution Process (EIRP) for the original RRCCP. At the recommendation of this workgroup, a study designed to evaluate site-specific settling rates was funded by the USACE and conducted by the Corps of Engineers Waterways Experiment Station (now ERDC) (Schroeder and Toro 1996). The study involved collection of water and suspended materials from Lake Texoma and laboratory determination of settling rates at various levels of TDS reduction anticipated for the RRCCP. Results of this study can be reviewed at http://www.swt.usace.army.mil/LIBRARY/Library.CFM.

Reductions in chlorides and TDS for the proposed plan are much less than those associated with the original RRCCP. In general, the proposed project would result in an approximate TDS reduction of 7% relative to "natural" conditions excluding chloride control at Areas VIII, VII, and X. When chloride control at Area VIII is considered (this facility has been operational since 1987) the difference between these conditions and the proposed plan would be a TDS reduction of around 5%. Accordingly, TDS reductions for the proposed plan are considerably lower than those evaluated by Schroeder and Toro (1996).

In order to evaluate potential changes in Lake Texoma turbidity for the proposed plan for chloride control (Areas VIII, VII, and X in the Wichita River Basin), impacts of anticipated TDS levels from updated concentration/duration curves (USACE 2001a) with and without (excluding all three brine areas) the proposed plan on Lake Texoma settling rates were compared using site-specific information and methodology from Schroeder and Toro (1996). This involved application of regression equations relating TDS concentrations and sedimentation rate constants (1/hr) as presented in Figure 3 of

Schroeder and Toro (1996) to with- and without project TDS levels for the two initial turbidity levels (8 and 16 NTU) evaluated by these authors. The 8 NTU level approximates "normal" turbidity levels in Lake Texoma while the higher level (16 NTU) might represent elevated levels resulting from an event such as high inflow or wind-induced sediment re-suspension. Once sedimentation rate constants were developed using these methods, first order sedimentation was estimated using the equation:

$$N = N_0 e^{-kt}$$

where N is turbidity at time t, N_0 is the initial turbidity (t = 0), and k is the sedimentation rate constant (1/hr) derived as described above (Schroeder and Toro 1996). Resulting pre- and post-project turbidity values were compared as a measure of the differences that might be expected in turbidity reduction following a "turbidity inducing" event in Lake Texoma, with and without the proposed project. Results were obtained for 1, 5, 50, 95, and 99 "equaled or exceeded" TDS levels as contained in concentration duration curves (USACE 2001a). Evaluations were conducted for reaches representing the majority of Lake Texoma (Denison gage to approximately Lebanon on the Red River Arm) (Reach 5, Figure 3-1) and the extreme Upper Red River Arm of Lake Texoma and the Red River upstream of the lake (approximately Lebanon to the west Cooke County, Texas line) (Reach 6, Figure 3-1).

Results of pre- (natural) and post-(modified) project turbidity reduction evaluations for the 50% "equaled or exceeded" estimate for Lake Texoma (Reach 5, Figure 3-1) are shown in Figures 4-10 (8 NTU) and 4-11 (16 NTU).

For the 8 NTU evaluation, the maximum pre- and post-project turbidity difference is 0.10 NTU after approximately 3 days of settling with an average difference of 0.07 NTU over a 10-day settling period (Figure 4-10). Schroeder and Toro (1996) defined "final" turbidity changes as differences in turbidities following 7 days of settling. For the 8 NTU evaluation (Figure 4-10), this difference in final turbidity is 0.05 NTU.

For the 16 NTU evaluation (Figure 4-11), the maximum turbidity difference is 0.19 NTU after approximately 3 days of settling with an average difference of 0.13 NTU over a 10-day settling period. Difference in "final" turbidity for this initial turbidity level is 0.11 NTU. For conditions approximating high flow periods (99% exceedence, 16 NTU), average pre- and post-project differences over a 10-day settling period would be 0.15 NTU.

Based on these analyses, predicted differences in pre- and post- project turbidities for the majority of Lake Texoma are extremely small and are within the accuracy range and near the limits of resolution of scientific instruments which measure field turbidity.

FIGURE 4-10
PRE- (NAT) AND POST-(MOD) PROJECT TURBIDITY FROM 8 NTU INITIAL TURBIDITY
LAKE TEXOMA

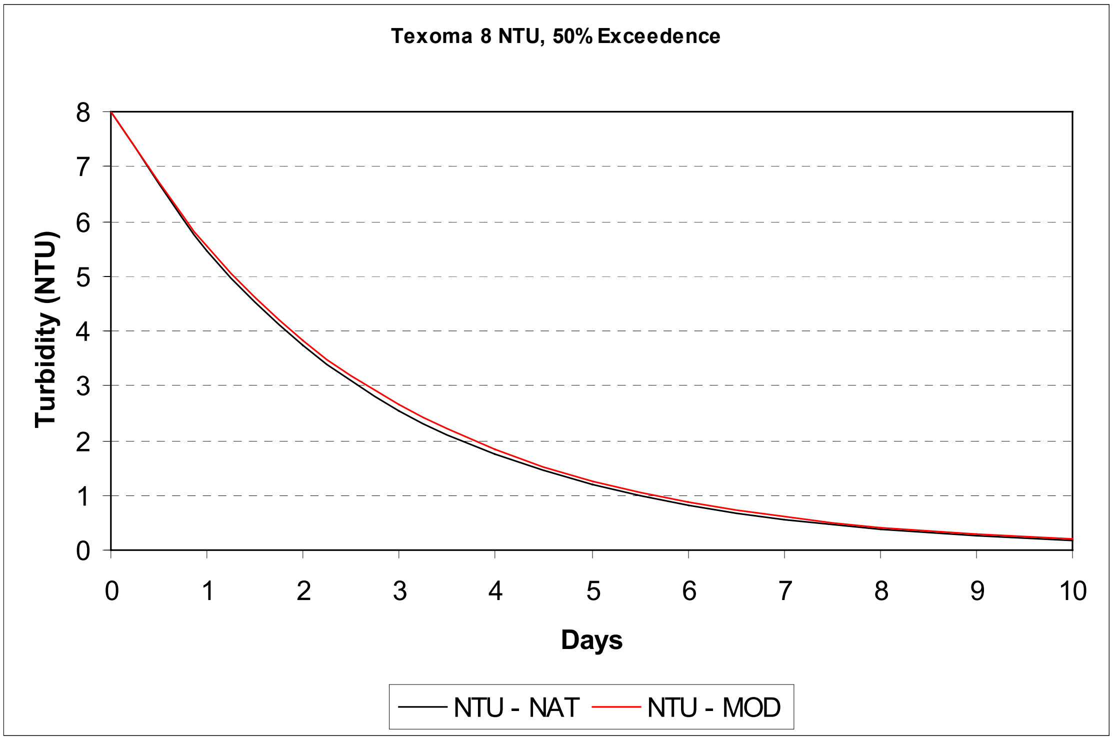
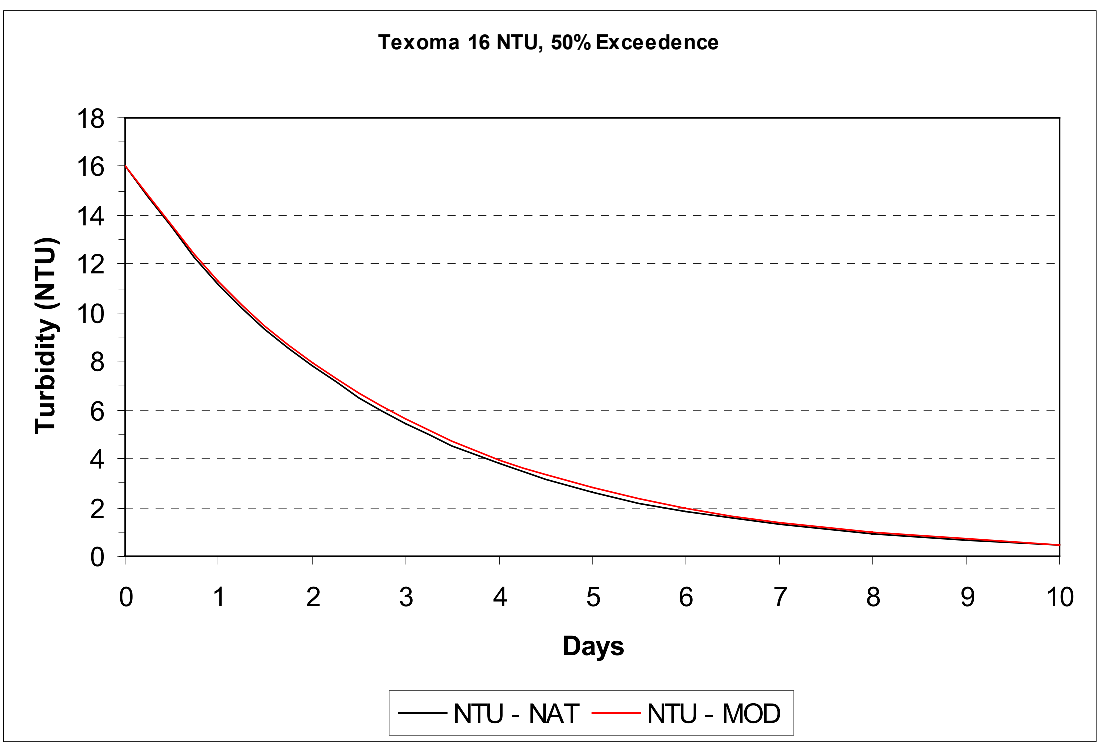


FIGURE 4-11
PRE-(NAT) AND POST-(MOD) PROJECT TURBIDITY REDUCTIONS, 16 NTU
LAKE TEXOMA



Results of pre- and post-project turbidity reduction evaluations for the 50% "equaled or exceeded" estimate for the extreme upper end of the Red River Arm of Lake Texoma and the Red River above the lake (Reach 6, Figure 3-1) are shown in Figure 4-12 (8 NTU) and Figure 4-13 (16 NTU). Differences are much smaller than those for the majority of Lake Texoma.

For the 8 NTU evaluation, the maximum pre- and post-project turbidity difference is 0.03 NTU after approximately 2 to 3 days of settling with an average difference of 0.02 NTU over a 10-day settling period (Figure 4-12). Difference in "final" turbidity is 0.01 NTU. For the 16 NTU evaluation (Figure 4-13), the maximum turbidity difference is 0.01 NTU after 2 to 3 days of settling with an average difference of 0.006 NTU over a 10-day settling period. Difference in "final" turbidity for this initial turbidity level is 0.005 NTU. For conditions approximating extreme high flow periods (99% exceedence, 16 NTU), average differences with the proposed project would be less than 1 NTU (0.95 NTU).

FIGURE 4-12
PRE-(NAT) AND POST-(MOD) PROJECT TURBIDITY FROM 8 NTU INITIAL TURBIDITY
REACH 6

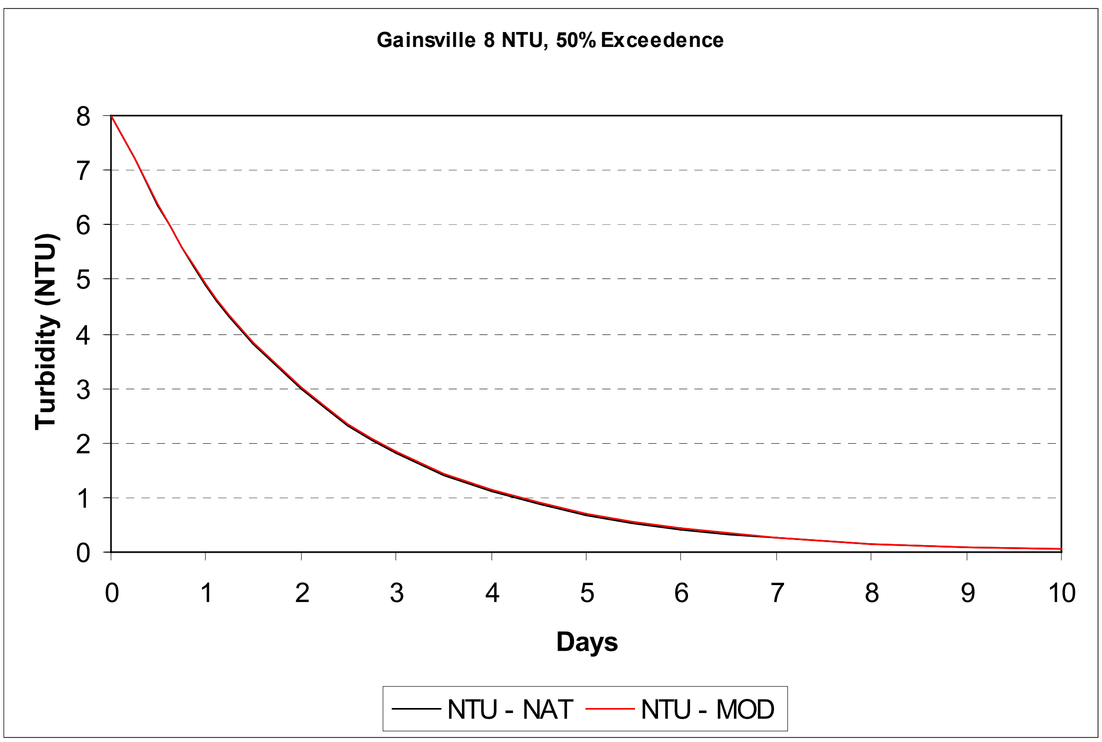
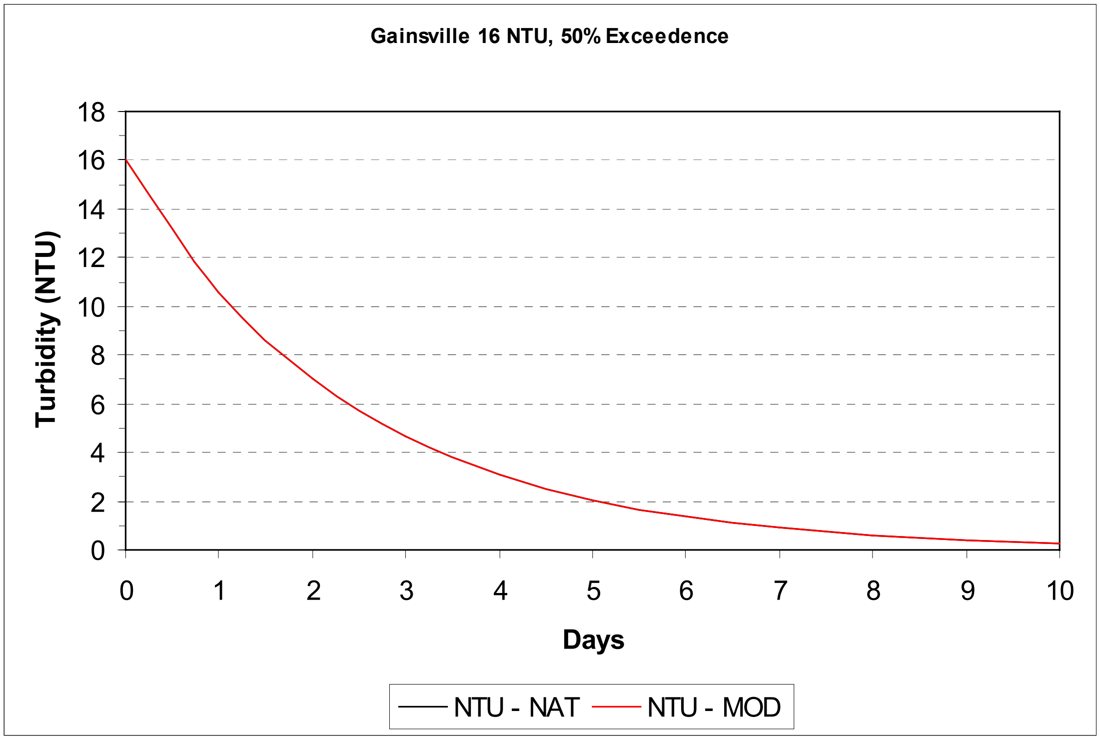


FIGURE 4-13
PRE-(NAT) AND POST-(MOD) PROJECT TURBIDITY FROM 16 NTU INTIAL TURBIDITY
REACH 6



In summary, anticipated changes in solids settling dynamics and turbidity in Lake Texoma and the Red River above the lake were evaluated using site-specific settling data. Resulting differences were estimated to be extremely small, if even quantifiable using turbidity-measuring instrumentation. Accordingly, project-related impacts associated with turbidity-induced decreases in reservoir primary productivity, associated impacts on the lake fishery, reduced aesthetics, impaired recreational value, or other turbidity-related impacts would not be expected to occur with project implementation.

(c) Nutrient Cycling and Plankton Dynamics. Other issues concerning the proposed project and Lake Texoma reservoir water quality include impacts of reduced salts on nutrient (nitrogen and phosphorus) cycling as well as plankton dynamics. Environmental factors governing populations of these planktonic organisms are extremely complex and difficult to define. While major changes in salinity (marine to fresh water) would most likely result in significant shifts in Lake Texoma planktonic assemblages, significant impacts to plankton associated with the relatively minor magnitudes of chloride reduction associated with the proposed project would not be anticipated.

The conceptual basis for impacts on reservoir nutrient cycling involves altered bio-geochemical processes affected by changes in reservoir stratification patterns and significantly reduced sulfate loading. Data indicate that reservoir sulfate concentrations would be only minimally impacted by the proposed project (USACE 2001a). Impacts resulting from significant changes in sulfate levels would, therefore, not be anticipated.

Several factors have been reported to influence the vertical stratification of Lake Texoma including TDS (Hubbs *et al.* 1976, Matthews and Hill 1988) and salinity (Clyde, unpublished data). Because impacts to these factors are considered to be minimal, impacts on nutrient cycling due to changes in stratification patterns are not anticipated.

2. Lake Texoma Fish Communities. As discussed previously, some members of the public and resource agencies have expressed concern regarding the changes in the water quality in the Wichita River and what effect the change in the water quality of the river would have on fish communities in downstream reservoirs including Lake Texoma. Much of the concern has focused on increased turbidity due to the reduction in salinity (TDS) in Lake Texoma and the potential impact on the striped bass fishery in the lake. An economic study indicated that expenditures, both direct and indirect, of Lake Texoma anglers are in excess of $28 million annually, of which striped bass anglers account for over 60% (Schreiner 1995).

The potential impacts of the project on striped bass (*Morone saxatilis)* spawning and recruitment in Lake Texoma is an additional concern expressed by the natural resource agencies. This concern relates to potential impacts on striped bass reproduction from reduced chloride concentrations and flow changes, based on the theory that striped bass are a marine species introduced into a freshwater environment. In reality, they are an anadromous species, a marine species that migrates up freshwater streams to spawn. Reservoir populations throughout the country, including Oklahoma, were developed from anadromous populations of striped bass that ascended East coast and Gulf coast rivers to spawn in fresh water. Setzler *et al.* (1980) reported that factors which affect reproduction to the greatest extent are water flow (volume and velocity), temperature, and dissolved oxygen. Salinity, although reported to block spawning in some rivers and to decrease egg buoyancy due to inhibiting egg expansion, is cited as having a positive effect on larval survival (Albrecht 1964). A comprehensive synopsis of the reproductive biology of striped bass is given by Shelton (1996) in a draft literature survey prepared for the Lake Texoma workgroup.

Successful striped bass reproduction in fresh water is well documented in Oklahoma. Striped bass in Oklahoma were originally stocked with hatchery-produced fish (fry and fingerlings) from anadromous populations. Supplemental stockings in Oklahoma reservoirs were from striped bass eggs successfully hatched at Byron State Fish Hatchery and the Durant State Fish Hatchery. Both use water of low chloride concentrations. The Byron Fish Hatchery uses groundwater from the Ogallala Aquifer with a salinity of 130 mg/l (OWRB 1980). The Durant Fish Hatchery uses water from the Blue River for its operations which has a mean salinity of 15 mg/l. Both are significantly less than existing salinities of the Red River (>577 mg/l) and predicted salinities in the river during operation of the project. Likewise, successful natural spawning has been reported in reservoirs with salinity concentrations much less than those presently observed in the Red River or expected with the RRCCP. Physiological stresses or problems with egg viability due to lower salinity have not been observed in Keystone Reservoir or in the Washita River in Texoma Reservoir. Striped bass have successfully spawned in the Arkansas River above Keystone Reservoir (mean annual salinity = 554 mg/l) annually since 1970. Conversely, spawning rarely occurred on the Cimarron River tributary of Keystone Reservoir, where mean annual salinity is 3,947 mg/l. Finally, successful spawning of striped bass is well documented in the Washita River (USFWS 1989), the other major tributary of Lake Texoma, which has a mean salinity of only 110 mg/l, well below that expected in the Red River with the project in place.

Potential effects of the proposed project on turbidity in Lake Texoma were discussed in detail in the previous section and it was concluded that the proposed project salinity reductions would likely have a very small effect upon the turbidity of Lake Texoma during normal conditions.

These small effects on the turbidity levels in Lake Texoma would not be expected to have a detectable effect on the sport fishery (including striped bass) of the lake.

Operation of the proposed project would not significantly alter medium or high flows at source control areas within the main stem of the Red River. High flows associated with spawning striped bass would remain relatively unchanged with the proposed project. Therefore, reduced flows from the proposed project should not be an issue with respect to striped bass reproduction.

3. Recreation. Study of Lake Texoma by the USACE (2001b) revealed that under natural conditions, the chloride concentrations at Lake Texoma equal or exceed 165 mg/l 99% of the time and are greater than 345 mg/l 50% of the time. With implementation of the proposed project, chloride concentrations would equal or exceed 147 mg/l 99% of the time and would be greater than 309 mg/l 50% of the time. This represents a 10% reduction in chloride concentrations at Lake Texoma that is anticipated to produce imperceptible turbidity changes at the lake.

If visually perceptible by recreational users, a change in clarity of Lake Texoma might have an impact on water-based recreation. The relationship between the degree of clarity and perception by recreation users is not well defined nor is it readily measurable. Even if that relationship was established, turbidity studies predict little to no noticeable effect on lake clarity. According to Chinzinski *et al.* (2001), the general public is unable to detect changes in vials of water that contain less than a ten-fold increase in turbidity. Therefore, even a significant change in turbidity would unlikely be detected by the general public using Lake Texoma for recreational purposes. Thus, the project should have little or no impact on lake aesthetic values or recreation use that might be associated with lake clarity.

4. Water Supply. Water quality improvement at Lake Texoma would be minimal, with reductions of approximately 10%, 5%, and 7.5% for chloride, sulfates, and TDS, respectively at the 50% exceedence level. Therefore, water quality is anticipated to change only minimally. However, in contrast to the minimal effect such changes have on recreation or fish communities, benefits to municipalities and industry may be realized because these users are more sensitive to incremental water quality improvement. Municipal and industrial users would benefit and would blend water from Lake Texoma resulting in greater consumption. With increased water use for water supply, there may be changes in lake level fluctuations at Lake Texoma. However, additional water supply storage should not be required as a result of the project. If needed, this storage would be provided by reallocating storage from hydropower to water supply.

5. Hydropower. In June 1993, USACE conducted an economic Limited Reevaluation Report (LRR) for the project. The report addressed potential impacts on hydropower revenue at Denison Dam. Those impacts are based on a reduction of inflows from the Red River into Lake Texoma due to potential increases in water for irrigation. It is not anticipated that removal of brine flows from Areas VII and X (Area VIII is already operational) would directly affect flows into Lake Texoma. Flows in Reaches 6 and 8 are not anticipated to be affected by the proposed plan nor is flow in the Red River.

With increased water use for water supply, there may be changes in lake level fluctuations at Lake Texoma. Just as is currently practiced, when pool levels drop below elevation 612 feet NGVD, hydropower generation would be reduced in accordance with Public Law 100-71 (July 11, 1987).

n. Economic Impacts.

1. Areas Above Lake Kemp. The land along the Wichita River above Lake Kemp, in addition to the North and South Forks of the Wichita River, are privately owned. However, the rivers and associated riverbeds provide fishing and limited all terrain vehicle (ATV) use when access is attained. No reservoirs exist along the Wichita River above Lake Kemp within the project area. Impacts to recreation opportunities on private lands along this portion of the Wichita River may occur as a result of the project; however, the degree of impact cannot be determined because formal designated recreation opportunities have not been identified. Further, the economic impacts as related to recreation are difficult to quantify.

2. Areas Below Lake Kemp and Above Lake Texoma. Recreational opportunities between Lake Kemp/Diversion and Lake Texoma are limited due to the large amount of private land along the Wichita and Red rivers. No reservoirs exist along the main stems of the Wichita or Red rivers between Lake Kemp/Diversion and Lake Texoma. Implementation of the proposed plan is unlikely to result in direct economic impacts on the recreation industry. The proposed plan is not anticipated to result in drastic alteration of local flora and fauna which would impact local hunting and fishing habits and consequently local economies.

3. Areas Adjacent to Lake Kemp. Some members of the public and agencies have expressed concern about the changes in water quality in the Wichita River and its impact on area economics. Chizinski *et al.* (2001) study found that Lake Kemp recreation spending accounted for $425,269 of expenditures in Baylor County, $983,664 of expenditures in a 10-county region surrounding Lake Kemp and $1,508,471 of expenditures in the State of Texas. These are expenditures related to Lake Kemp use. These expenditures are not solely attributable to the availability of Lake Kemp as a recreation resource, as there are a number of other substitutes for Lake Kemp expenditures, including other forms of recreation and expenditures.

4. Areas Adjacent to Lake Texoma. Natural resource agencies are concerned that a reduction of chlorides in the Wichita and Red rivers would impact the clarity of Lake Texoma, potentially causing a reduction in primary productivity of the lake which could, in turn, impact the number of fish caught by anglers. Their concern is that a decrease in fish harvest may result in fewer anglers coming to the lake. With fewer anglers, there would be fewer expenditures for recreation-related activities in areas surrounding the lake. The overall effect could be a potential decrease in economic activity in areas surrounding Lake Texoma.

Estimation of the decrease in economic activity related to decreased fish catches (if they even were to occur) at Lake Texoma is not considered significant. Angler expenditures account for less than 1% of the surrounding counties' regional income. Walsh (1986) cited several studies which indicate that recreation use depends on a variety of site characteristics, including crowding, availability of facilities, noise, weather conditions, and fish harvest rates. There is no evidence to indicate a direct relationship between catch rates and angler visitation or expenditure. In addition, those who opt not to fish at a site because of decreased catch rates may not have the same spending habits as those who elect to fish. Because of the complexity of recreation behavior, such as fishing, the relationship between lake clarity and recreation expenditures is difficult to quantify, although a study was completed to make an effort to assess the impacts from the project.

o. Cumulative Impacts. The combined, incremental effects of human activity, referred to as cumulative impacts, are in some cases a serious threat to the environment. While they may be insignificant by themselves, cumulative impacts accumulate over time, from one or more sources, and can result in the degradation of important resources. Because Federal projects cause or are affected by cumulative impacts, this type of impact must be assessed in documents prepared under NEPA.

The assessment of cumulative impacts in NEPA documents is required by CEQ regulations (1987). Cumulative impacts result when the effects of an action are added to or interact with other effects in a particular place and within a particular time. It is the combination of these effects, and any resulting environmental degradation, that is the focus of this cumulative impact analysis. Cumulative impacts for the proposed plan have been identified through discussions with resource agencies and interest groups. These impacts center around productivity at Lake Texoma.

1. Lake Texoma Productivity. Currently, no data exist to show that the productivity resource at Lake Texoma is especially vulnerable to incremental effects or that salinity issues have been historically significant. The proposed project is the only salinity control project proposed for the Red River Basin. The proposed project would be combined with previous activities (Areas VIII and V) completed as part of the original RRCCP. As such, the project does have the potential for cumulative impact. This is perhaps the greatest perceived potential for cumulative impacts. However, the primary potential for cumulative impacts actually exists in that other activities, primarily lake aging and eventual closure, would have a concurrent (in terms of proposed project life) effect on lake productivity.

Denison Dam and Lake Texoma were authorized for construction by the Flood Control Act approved June 28, 1938 (Public Law No. 761, 75th Congress, 3rd Session) for flood control and generation of hydroelectric power. The dam, spillway, and outlet works were started in August 1939 and completed in February 1944. When completed in 1944, Denison Dam was America's largest rolled, earth-filled dam. The dam is now the 12th largest in volume in the United States. The project was put into operation for flood control in January 1944. The lake has recently been reevaluated with a remaining life of 87 years (USACE 1993c).

Resource agencies and community groups have expressed concerns with respect to cumulative impacts at Lake Texoma. In summary, while the 2% reduction in TDS as a result of Area VIII and Area V construction has not resulted in notable impacts at Lake Texoma, groups are concerned that an additional 5% TDS reduction would have detrimental effects. Decreases in salinity, though limited, are thought to exacerbate decreases in lake productivity by a variety of pathways, including turbidity changes, nutrient cycling dynamics, plankton production, and fish recruitment. Although analysis of these factors shows minimal impact to the lake, concerns persist among resource agencies that reductions in lake productivity would occur over the project economic lifetime (100 years).

Comparison of the project life to the lake life shows that the lake is anticipated to approach minimum productivity close prior to the project's end. As a consequence, lake productivity would decline over time due to siltation and eutrophication without the project's implementation. Siltation occurs as a natural process in reservoirs because reservoirs act as a settling basin. Solids suspended in turbulent waters entering the lake settle out, resulting in lake clarity and low lake turbidity compared to the contributing streams. This process also results in a gradual buildup of silt in the lake. Lake Texoma is currently on the Section 303(d) impaired water body list due to siltation. Siltation eventually compresses depths below the thermocline such that thermal refuges are minimized and productivity decreases. Large fish are most affected by the lack of thermal refuges. Consequently, catches in the lake gradually decrease in size. An analogous case is the decline of Lake Keystone, Oklahoma fisheries over the past 20 years as a result of lake siltation and loss of thermal refuges.

Eutrophication is a condition in an aquatic ecosystem where high nutrient concentrations stimulate blooms of algae (e.g., phytoplankton) (Table 4-16). Although eutrophication is a natural process in the aging of lakes and some estuaries, human activities can greatly accelerate eutrophication by increasing the rate at which nutrients and organic substances enter aquatic ecosystems from their surrounding watersheds. Agricultural runoff, urban runoff, leaking septic systems, sewage discharges, eroded streambanks, and similar sources can increase the flow of nutrients and organic substances into aquatic systems.

TABLE 4-16
TROPHIC STATES

Oligotrophic	Clear waters with little organic matter or sediment.
Mesotrophic	Waters with more nutrients, and, therefore, more biological activity.
Eutrophic	Waters extremely rich in nutrients, with high biological activity. Some species may be choked out.
Hypereutrophic	Murky, highly biologically active waters, closest to the wetland status. Many clearwater species cannot survive.
Dystrophic	Low in nutrients, highly colored with dissolved humic organic material. (Not necessarily a part of the natural trophic progression.)

Source: EPA, 2000

These substances can overstimulate the growth of algae, creating conditions that interfere with the recreational use of lakes and estuaries and the health and diversity of indigenous fish, plant, and animal populations. Algal blooms hurt the system in two ways. First, they cloud the water and block sunlight. Second, when the algae die and decompose, oxygen is depleted. Dissolved oxygen in the water is essential to most organisms living in the water, such as fish. Lake Texoma is currently classified as mesotrophic based on *chlorophyll-a* concentrations (> 4 µg/l and < 10 µg/l) (Ground and Groger 1994).

Productivity declines are not anticipated at Lake Texoma due to the proposed project. However, some resource agencies and interest groups are insistent that such changes would occur as a result of the project. USACE studies show there would be minimal impacts. However, it must be acknowledged that significant productivity declines would occur without the project.

p. Operation and Maintenance (O&M) Requirement. The various types of O&M activities associated with operation of the project were described in Section 4 of the 1976 FES for the RRCCP. These activities generally include general maintenance and repair of inflatable rubber dams, access roads, pumping units, monitoring wells, and collection pipelines. Additional types of O&M activities associated with the proposed project could include maintenance of spray fields, management activities associated with the Crowell Lake fish and wildlife mitigation lands, and monitoring activities associated with implementation of the EOP features.

The EOP (Appendix A) for the proposed project was developed for evaluation, monitoring, and, if necessary, remediation of any effects of the proposed project. An Implementation Schedule and estimate of implementation cost are included in the EOP. The different general areas addressed in the EOP include:

- Stream water quality;
- Lake Kemp water quality;
- Refugia habitat;
- Brush management; and
- Selenium monitoring.

Monthly water sample collection and chemical analyses by the USGS were initiated at a number of gage locations in the basin in 1996 for stream water quality. This monitoring effort would continue.

Monitoring of Lake Kemp was also conducted during this time frame. Under the proposed project, concentrations of chloride, sulfate, sodium, calcium, as well as nutrient and chlorophyll *a* data would be evaluated to determine if any changes relative to historical data are occurring.

Monitoring data would also be used to evaluate the viability and effectiveness of potential remedial actions to maintain refugia pools. A minimum of ten refugia sites within reaches of special concern would be established. Measures would be implemented at these sites to attempt to provide refugia for fish under dry conditions if studies indicate they are warranted. Measures under consideration include pumping of water from the surrounding alluvium into refugia pools, aeration and recirculation of water within refugia pools, and temporary releases from storage reservoirs to augment flows and pools.

The brush control program has currently been included in Texas Senate Bill 1 and the Region B Water Plan. Implementation of the program is expected to occur regardless of decisions made on the proposed project. The objective of monitoring the brush control program is to document changes in land use. Beginning 5 years after completion of the environmental baseline study, and continuing at 5-year intervals throughout the project life (100 years), the maps and data on environmental conditions would be updated. New imagery of the study area would be obtained, field checks would be made to ensure accuracy of data, and differences between old and new imagery would be analyzed and quantified.

Data would also be collected and analyzed to support decisions aimed at avoiding development of toxic concentrations of Se at proposed project areas. Ecosystem components to be monitored for Se include:

- Water;
- Sediment;
- Fish;
- Invertebrates (if possible); and
- Avian eggs.

q. Mitigation Proposals. A Mitigation Plan for the proposed project has been developed and is included in this document as Appendix B along with the District's analysis of the USFWS CAR. Following is a summary of conditions for mitigation and measures evaluated in the plan.

1. Base Conditions. Due to growing concern in the Wichita River Basin about the availability of water and its effect on economic growth and development, brush control has been evaluated by the State as a means to increase watershed yield. The goal is to restore large areas of brush to native grasses, but to leave brush buffers and habitat corridors along streams. The proposed brush control program is expected to provide a net increase in overall watershed yield measured at Lake Kemp. The brush control program has currently been included in Texas Senate Bill 1 and the Region B, or RRA, Water Plan. Implementation is expected to occur regardless of the outcome of the Reevaluation. The Reevaluation has used a brush management factor of 50% implementation as its future condition.

Economic evaluation of the project has been developed in terms of June 2001 price levels. Annualized costs have been developed using the current Federal discount rate for fiscal year (FY) 2001 of 6-3/8%.

2. 1976 FES and Mitigation Proposals. In accordance with the Fish and Wildlife Coordination Act, the project was coordinated with the USFWS and natural resource agencies of affected states. The USFWS CAR for the authorized RRCCP, dated May 4, 1976, and USACE's response to their recommendations were included in Design Memorandum No. 25 dated July 1976. Overall, these agencies concurred with the project in 1976.

Authorized mitigation recommendations for the project included fee acquisition, fencing, and developing approximately 10,000 acres of project land at Canal Creek (Crowell) and making it available to the TPWD for wildlife management purposes. Both Oklahoma and Texas concurred in the May 4, 1976, report.

3. 2002 SFES Proposed Mitigation. Owing to design changes in the original RRCCP, changes in existing project conditions for the project area, amendments to the Endangered Species Act, and the presence of additional species since filing of the FES, it was determined that a supplement to the FES would be required. The project was recoordinated with the resource agencies in accordance with the Fish and Wildlife Coordination Act, and the USFWS issued a Final Fish and Wildlife Coordination Act Report (CAR) for the project dated May 8, 2002.

According to the CAR, the USFWS and the ODWC are unable to support the proposed plan in its present form and recommend that it not go forward as formulated due to impacts to fish and wildlife resources. Unmitigable impacts from the proposed plan were projected for the Wichita River aquatic community; Lake Texoma, Lake Kemp, and Lake Diversion sport fisheries; the Dundee State Fish Hatchery; and Migratory birds and other resources potentially impacted by Se at Truscott Brine Disposal Reservoir. The CAR recommends that other alternatives, such as desalinization and water blending, be evaluated for water supply and pumping to streams or deep well injection be evaluated instead brine disposal at Truscott Reservoir. These would be integrated into a new limited project that meets the water requirements of the Wichita River Basin (USFWS 2002). However, the USFWS is opposed to any attempt to accomplish the objectives of the RRCCP in stages (USFWS 2002).

Since 1991, the USACE has conducted additional environmental studies to address reasonable foreseeable impacts. Based on this technical information, the USACE disagrees with the Service as to the severity of impacts attributable to the chloride control measures. The USACE’s position with respect to the project remains unchanged for the following reasons:

(1) Project output has changed since the project was originally formulated. The project would be operated for target chloride concentrations of 300 mg/l or less 40% of the time at Lake Kemp with minimal reductions in chlorides (10% overall) at Lake Texoma.

(2) Technical data do not substantiate that the proposed plan would have a significant impact on turbidity and primary productivity in Lake Kemp, Diversion, or Texoma. In fact, turbidity impacts at Lake Texoma approach zero. Minimal, if any, impacts to turbidity, primary productivity, fisheries or recreation would be expected to occur at Lake Texoma and minimal potential impacts would likewise be expected at Lakes Kemp and Diversion.

(3) Additional environmental studies conducted by USACE during preparation of the DSES indicate some short-term changes to aquatic communities of the upper Wichita River may be

likely to occur, but not with the severity reported by the USFWS and natural resource agencies.

(4) The EOP developed for the proposed plan establishes comprehensive and scientifically valid methodologies for establishing existing baseline conditions, establishes environmental thresholds and safeguards for many system components, provides long-term monitoring for impacts attributable to the chloride control measures, and protects against unacceptable changes in the Wichita and Red River ecosystems as well as in Lakes Kemp and Diversion. More importantly, it provides a commitment by the USACE to balance authorized project goals with the need to maintain the biological resources throughout the life of the project. The commitments agreed upon in the EOP are summarized in Section 4 of the SFES.

(5) The fully developed project provides the operational flexibility to meet target chloride concentrations while minimizing impacts to the ecosystem. As part of the EOP, chloride concentrations would be continuously measured at target locations and numerous gaging stations throughout the project area to monitor project performance. Results of chloride measurements from this monitoring network would be used to adjust operations at control sites (including elimination of some control sites, if warranted) to balance authorized project goals with the need to maintain biological resources.

(6) The USACE and the project sponsor recognize the potential for change to occur within the project area ecosystem with construction and operation of the chloride control measures. The USACE believes that the project could be constructed and operated to meet project goals while assuring the continued function and integrity of the ecosystem and as such, under the intent of NEPA and other appropriate environmental laws and regulations, would: (a) fund and implement the baseline studies and monitoring activities developed and proposed in the EOP, (b) review and act on the recommendations of the peer review committee, and (c) consider for implementation these recommendations, including recommendations to Congress, to suspend operation of the project if unacceptable environmental impacts result from construction and operation of the project.

The USACE believes that by implementing appropriate and reasonable mitigation measures and developing and implementing the EOP, the project should <u>not</u> be discontinued or reformulated. Mitigation measures for the proposed project would address the following topics.

(a) <u>Fish and Wildlife</u>. Mitigation for losses of terrestrial wildlife habitat would be accomplished at the Crowell Mitigation Area. Crowell was designed and authorized as a brine storage lake for Areas VII, IX, and XV and the mitigation area for the entire RRCCP. The site is on Canal Creek, a tributary of the Pease River. The location is about 8 miles northwest of the town of Crowell in Foard County, Texas. Authorized mitigation for the RRCCP included: fee acquisition, fencing, developing about 10,000 acres at the reservoir, and making those lands available. Construction of the embankment has been indefinitely delayed. The completed acquisition, increased through the acquisition of uneconomic remnants, has placed 11,933 acres of mitigation lands under Federal ownership.

Mitigation for losses of aquatic brine habitat is considered an unmitigable loss. The goal of the proposed project is to reduce brine loadings to the Wichita River. One consequence of the proposed project is, therefore, the conversion of brine aquatic habitat to relatively freshwater habitat. In areas upstream of the chloride collection facilities in operation, the structure of the fish community is relatively simple comprised primarily of Red River pupfish, plains killifish, and mosquitofish. The Red River pupfish and plains killifish can tolerate high salinity levels and may be found in water with salinity greater than 100,000 mg/l, which is roughly three times the concentration of seawater (Echelle *et al.* 1972). Echelle *et al.* (1972) found that, although Red River pupfish are present in low relative abundance within waters with low salinity, they are only highly abundant in waters with salinity greater than 10,000 mg/l, where few other species are present. Conversely plains killifish can successfully compete in freshwater environments with a wide range of salinities.

With installation and operation of the inflatable dams, upstream movement of fish would be curtailed except during periods of high flows when the dams would be deflated. However, physical constraints (concrete dam apron) and flow conditions (water velocity over the deflated dam) would not be conducive to upstream movement of fish during periods of high flows. The fragmentation of the fish populations would serve to reduce the gene flow between the upstream and downstream populations. This would be of concern for only the fish communities located upstream of the dams. During high flow periods, some of the individuals located upstream would be carried over the dam. This concern would be the greatest for the Red River pupfish, which has an extremely limited distribution.

(b) Selenium. Brine pumping from tributaries of the Wichita River has the potential to provide benefits to the stream in terms of Se-impacts. Portions of the Wichita River Basin are currently Section 303(d) listed due to impairment by Se. The proposed plan could provide a benefit to the upper Wichita River in terms of reduced Se-impacts. However, the potential for similar impacts could be transferred to Truscott Brine Disposal Reservoir.

Significant Se-impacts at Truscott Brine Disposal Reservoir do not include human health risks from either contact, ingestion of water, or consumption of waterfowl. The primary potential impact does lie with sedentary semi-aquatic breeding birds nesting at the reservoir.

Considerable discussion has taken place with resource agencies regarding potential Se-related impacts and possible remedial measures for avoiding or minimizing these impacts, should they occur. While the USACE is committed to taking remedial actions for avoiding Se impacts, should they appear likely to occur, it believes that the Truscott Brine Disposal Reservoir can be operated safely under the proposed plan. Based on the USACE's best estimate, Se-related impacts, if any, would occur well into the project life.

With respect to Se remediation, several general categories of potential remedial measures are conceivable given current knowledge of the subject. These categories are provided as examples of potential measures. Site-specific relevance as well as technical or economic feasibility would vary for these measures and may or may not be appropriate for this project. Brief descriptions of potential measures, should they be warranted, are provided below.

- Habitat Alteration to Discourage Nesting of Impacted Bird Species. If Se-related impacts associated with the project were to occur, these impacts would most likely be associated with decreased reproductive capacity of birds nesting near Truscott Brine Disposal Reservoir. If potentially impacted species can be identified through monitoring, it may be possible to alter limited nesting habitat requirements to discourage nesting of these species in the project area. As a single example, if the affected species prove to be cormorants nesting in inundated dead snags, mechanical removal of these trees may be possible, forcing these birds to abandon the project area in search of more suitable nesting sites. Similar alterations (e.g., placement of riprap or control of shoreline slopes) to shorebird nesting habitat (if it exists and is limited in areal extent) could be implemented if monitoring identifies these species as affected.

- Food Chain Alteration/Elimination. As Se-related impacts are largely related to food chain dynamics of aquatic systems, Se impacts could conceivably be mitigated by altering and/or eliminating specific populations of organisms (e.g., algae, invertebrates, fishes) resulting in Se bioaccumulation and transfer to higher organisms (most likely bird species). Due to high chloride levels, species diversity of these aquatic organisms would likely be limited (though numbers of individuals could likely be high) and subject to possible control through alteration in habitat or physicochemical means. Monitoring efforts could identify species for possible control.

- Bioremediation. Bioremediation techniques involve the use of aquatic organisms in reducing Se levels. Potential treatment systems using bacteria, algae, aquatic plants, and other organisms could be investigated for their applicability to the project. Phytoremediation using Se-accumulating plants (e.g., canola, kenaf) is an emerging technology receiving increased research attention and is proving promising for Se treatment under certain conditions (Terry and Zayed 1998). Brine inflows could potentially be transported through such systems for reduction of Se loading to Truscott Brine Disposal Reservoir if necessary.

- Enhanced Volatilization. Atmospheric volatilization has proven to result in significant loss of Se mass in certain aquatic systems (see discussion in USACE 1994). This technique is particularly favorable due to permanent loss of Se from these systems. Volatilization rates are dependent upon a number of physical, chemical, and biological interactions but have been artificially increased with certain amendments. Site-specific research and alteration of conditions favorable to volatilization could conceivably be used to reduce Se mass in project waters.

- Alternate Habitat Construction Using Habitat-Based Protocol. Another potential remedial technique for Se-related impacts associated with the Wichita River Basin Project could be implementation of habitat-based protocols for Se based on those developed by the USFWS (1995a, 1995b). These protocols, one for determination of compensation habitat and the other for determination of alternative habitat required for impact avoidance, are based on the concept of landscape-level dilution of avian exposure to Se and have been applied in the San Joaquin Valley of California. These protocols could potentially be modified (if necessary) to be applicable to the Truscott Brine Disposal Reservoir or other project features.

- Hazing. Hazing is the intentional disturbance of birds with the intent to keep them from inhabiting certain areas. Hazing has sometimes been employed to prevent crop destruction by birds. Hazing could potentially be employed during the breeding season as a low cost and effective measure to prevent nesting by birds potentially at risk to Se exposure.

- Induced Changes in Se Speciation. While dynamics of Se speciation are currently poorly understood, it is known that certain Se species are more prone to bioaccumulation and manifestation of impacts on higher trophic level organisms.

Current research indicates that organic forms may be the most environmentally damaging in this respect. As research on this subject progresses, it may be possible to artificially control Se speciation in order to maintain forms with less bioaccumulation potential. Research continues in this area.

- Chemical Treatment. A potential, but currently costly alternative to mitigating Se-related impacts might be chemical treatment of brines for Se removal. While technically feasible (using techniques such as chemical coagulation with ferric sulfate), these techniques are currently costly in terms of chemical requirements and operation and maintenance costs relative to other measures. However, monitoring data could identify a reduced level of treatment balancing treatment costs and protection of the environment from Se impacts. Emerging technology in this area is likely over the life of the project and could prove useful in addressing Se concerns.

- Alteration/Management of Vertical Stratification Patterns in Truscott Brine Disposal Reservoir. Selenium species favored by chemically reduced conditions have low solubilities and may accumulate in deep sediments of vertically stratified aquatic systems. Removal of Se from the water column in these systems can reduce algal uptake, bioavailability, and impacts on higher trophic level organisms. It is very possible that permanent stratification due to brine-induced density differences may develop in Truscott Brine Disposal Reservoir, potentially reducing Se-related impacts. If needed, it is conceivable that stratification patterns favorable to Se reduction could be manipulated through future alteration of brine input elevations and flow patterns.

- Manipulation of Sulfur:Selenium Molar Ratios. Several authors have reported that sulfur may limit the bioavailability of Se (Maier *et al.* 1987) or provide significant protection against Se toxicity for certain organisms. Recent research has documented reduced Se bioaccumulation due to manipulation of sulfur:selenium ratios for both algae (Williams *et al.* 1994) and aquatic invertebrates (Hansen *et al.* 1993). Manipulation of elemental molar ratios could conceivably be used to minimize impacts in Truscott Brine Disposal Reservoir, if needed, and could prove particularly promising given high sulfate concentrations already present in this system.

- Operational Changes. Operational changes could include discontinued pumping of brines from one or more source areas. Ultimately, measures could also include discontinuation of the projects.

If measures listed above or other alternative means of control were employed, the range of potential remedial measures for alleviating Se concerns at Truscott Brine Disposal Reservoir or other project features could range from very simple and inexpensive to more complex, costly solutions. Based on current conditions and bird use patterns, some measure employing habitat alteration to discourage nesting semi-aquatic birds would appear particularly suitable for addressing Se-related impacts at Truscott Reservoir. Intensive bird use surveys during 1997 and 1998 revealed semi-aquatic breeding birds at the lake were limited in both species and numbers and utilized a limited, narrow range of habitat. It is likely that habitat alteration could have been quickly and inexpensively implemented during this period had Se concerns called for such action. While habitat alteration might prove useful under current patterns of bird use and habitat, these conditions could certainly change over the life of the project and require alternate remedial measures. These changing conditions and corresponding corrective measures would be addressed most efficiently by a process-based action plan as provided in the EOP (Appendix A).

(c) Dundee Fish Hatchery. Based upon analysis of water supply features at the Dundee Fish Hatchery, issues resulting from temporary elevation decreases in Lake Kemp or Lake Diversion can be mitigated by administrative and engineering means.

Under the Lake Kemp Drought Contingency Plan, the TPWD's Dundee Fish Hatchery below Lake Diversion would not receive water from Lake Diversion when Lake Kemp is below elevation 1123. Under the selected plan with 50% brush control at Truscott, Lake Kemp is at or above elevation 1123 feet NGVD 83.1% to 83.9% of the time. With brush control implemented in 50% of the basin, Lake Kemp is at or above elevation 1123 feet NGVD 85.2% to 88.3% of the time. Therefore, concerns have been raised with respect to water supply for the Dundee Fish Hatchery.

Elevation controls for hatchery water supply did not exist until development of Senate Bill 1 in 1999 and is not based upon actual water availability. This is a contractual issue established with the Wichita County Water Improvement District No. 2 and the TPWD and documented in legislation. During drought contingency conditions, water continues to be available from Lake Diversion for municipal and industrial use for a fee; further documenting that water supply is available. Changes to the Drought Contingency Plan can be accomplished through the legislative process or through the RRA, which has delegated authority for the Drought Contingency Plan in Water Planning Region B. Additional contractual negotiations could be conducted between the Wichita County Water Improvement District No. 2 and the TPWD for fee payment or waiver for water use during drought contingency conditions.

Lake Kemp and Lake Diversion are operated as part of the Wichita County Water Improvement District No. 2 irrigation system. Lake Kemp provides the storage and yield required for irrigation withdrawals and Lake Diversion provides the elevation necessary for delivery of water to the canal system. The flow inlets to the Dundee Hatchery consist of a 14-inch outlet at elevation 1047 feet NGVD and a 30-inch siphon outlet at elevation 1049 feet NGVD. The hatchery depends primarily on the 30-inch outlet. As a result, the Water Improvement District must maintain Lake Diversion between 1050 feet NGVD to 1052 feet NGVD year round to ensure the Dundee Hatchery an uninterrupted water supply. According to Water Improvement District personnel, if Lake Diversion were allowed to lower their elevation during the non-irrigation season, the Lake Kemp/Diversion system could increase their yield by as much as 10,000 acre-feet.

(d) Total Mitigation Proposal. Additional measures to be conducted for mitigation are addressed in the Mitigation Plan (Appendix B). Mitigation lands obtained previously for the RRCCP would be applied to the proposed project. No previously developed mitigation measures would be deleted by implementation of the proposed project.

5 COORDINATION WITH OTHERS

Coordination with others is an important aspect in preparation of the SFES for the proposed plan. This program has solicited input from the general public, local units of government, and interested agencies. This process has consisted of initial project scoping, agency coordination, and public information.

a. Scoping Process. As part of the NEPA requirements, a Notice of Intent was published in the Federal Register on July 22, 1998 announcing the intent to prepare a Supplement to the 1976 FES and providing a description of the project. A copy of the Notice of Intent is present in Appendix D. This notice began the scoping process. Scoping is part of the evaluation process outlined by NEPA. As such, the scoping process involves soliciting ideas from the public and others about the Reevaluation. In addition to public input, the USACE requested that Federal, State, and local agencies identify environmental issues related to the proposed project alternatives.

As part of the scoping process, two public information workshops were held by the USACE on December 9 and December 16, 1998. These workshops were conducted in Wichita Falls, Texas, and Durant, Oklahoma. A total of 26 people attended the Wichita Falls meeting and 13 attended the Durant meeting. Broadcast and print media attended both meetings. Attendees included representatives from the Red River Valley Association and the RRA as well as members of local and county government.

The purpose of the workshops were to inform the public about the beginning of the NEPA scoping process and the upcoming planning investigations on the proposed plan. The public also had the opportunity to provide comments and raise concerns about the project.

The workshops were designed as open house style meetings consisting of information stations and display boards. Instead of a formal presentation, USACE staff were on hand to answer any questions and discuss the project as attendees gathered information from the respective display stations. Information sheets discussing various parts of the investigation process were available at the different stations. Comment forms were also available for those who wished to leave comments or mail them to the Tulsa District, USACE office.

Key issues raised in the form of verbal and written comments (Appendix D) received during the scoping process included:

- The need for potable water. Members of local governments as well as local citizens and ranchers consistently and specifically expressed this concern.
- Support for improvements in Lake Kemp water quality.
- Frustration because of delays in the project and a reduction in the scope of the project to include only the Wichita River Basin rather than the entire the Red River system.
- Desire to further improve agricultural water quality, and, consequently, agricultural yields.
- Desire to protect flows into Lake Texoma and the lake's game fishery.
- Support for community water resources over protection of non-native striped bass population in Lake Texoma.
- Opposition to non-specific environmental impacts voiced by a local environmental group.
- Opposition to stream changes in the Wichita Basin.
- Opposition to any alternatives involving actions in Oklahoma.
- Questions regarding the benefit of basin-wide chloride control as opposed to point-of-use chloride control.
- The viability of the Wichita River Basin as an agricultural water source of sufficient volume compared to the benefit claimed for agriculture.

- Opposition to any alternative that involved a 100% Federal cost share rather than State or local cost sharing.

These issues are consistent with those anticipated at the beginning of the scoping process. Alternative analysis reflected the issues developed before and during the scoping process as found in this document and the Reevaluation.

A news release was issued and sent to newspapers and broadcast media in the areas surrounding Wichita Falls, Durant, and Sherman, Texas. Releases were distributed to 80 newspapers and electronic broadcasters. Advertisements for the public workshops were purchased in the Wichita Falls, Durant, and Vernon, Texas, newspapers. The *Dallas Morning News* and the *Wichita Falls Times Democrat* published articles on the project. Television stations in Sherman and Wichita Falls televised segments on local news programs about the project. The Associated Press circulated a story about the proposed project prior to the public workshops.

b. Agency Coordination. The SFES for the Reevaluation is subject to agency coordination under NEPA. The USACE notified Federal, State, regional, county, and local agencies for their input.

During the fall of 2001, the USFWS and the TPWD stated concerns about chloride control measures for the Reevaluation under evaluation by the USACE. In an August 2001 letter to the USACE, the USFWS stated their two biggest concerns and identified new concepts for chloride control. In a September 2001 letter to the RRA, the TPWD presented two primary, three secondary, and one continuing concern with respect to the proposed Reevaluation alternatives. In October 2001, the USFWS provided the USACE with a similar summary of the agency's initial impression of potential chloride control project impacts. Numerous conversations and several meetings between the USACE, USFWS, and TPWD were also completed during this time.

Concepts proposed by the USFWS and the TPWD were reiterated in a December 2001 letter from the USFWS to the USACE. Eventually, the concerns were developed into 12 proposed alternatives. These alternatives were evaluated by the USACE as part of this project.

The USACE has received a final CAR developed by resource agencies for the proposed plan. The final CAR, dated May 8, 2002, and USACE responses to CAR recommendations is included in Appendix C.

c. Additional Anticipated Coordination. The USACE is very interested in obtaining public input regarding the project. Consequently, the following actions have been/will be taken:

- A notice announcing the availability of this document (Notice of Availability) for review has been placed in the Federal Register. The public and agencies have 45 days from the date that the Notice of Availability was published to comment on this document.
- Approximately half-way through the 45-day comment period two formal public hearings will be advertised and held to solicit additional input with regard to this document and the proposed plan.
- Several copies of this document have been placed in the public libraries at Vernon, Wichita Falls, Durant, and Denison, Texas for review.

All substantive comments received on this draft document will be incorporated and addressed in the FSES. Copies of this document have been sent to the following for review and comment:

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